AN13642

i.MX RT Industrial Drive Development Platform Hardware Overview

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Document information

Information	Content
Keywords	i.MX, RT1170, multi-motor control
Abstract	This document presents the i.MX RT Industrial Drive Development Platform hardware: an NXP solution designed to reduce the development effort and time to market of secure multi-motor applications. The document describes the i.MX RT Industrial Drive Development Platform modular architecture and provides a detailed hardware description of the different components and their configuration.

1 Introducing the i.MX RT Industrial Drive Development Platform

The **i.MX RT Industrial Drive Development Platform** is a flexible and cost-effective modular-board kit that speeds up the development, evaluation and validation of complex multi-motor control applications for industrial robots, mobile robotics, multi-axis machineries, digital manufacturing, and many other industrial use cases.

The i.MX RT Industrial Drive Development Platform demonstrates how an **NXP i.MX RT1170 crossover MCU** can be leveraged to simultaneously control up to four Permanent Magnet Synchronous Motors (PMSMs) while at the same time handling advanced functionalities such as data logging, fault detection, deterministic connectivity (Ethernet TSN) and complex user interfaces. By leveraging on NXP EdgeLock SE05x secure element for the secure storage of keys and credentials, the i.MX RT1170 MCU also supports strong cybersecurity based on the latest, most secure cryptographic algorithms and protocols, therefore opening the path to achieve some of the highest security levels of the *ISA/IEC 62443-4-2* industrial standard.

The i.MX RT Industrial Drive Development Platform comes with a fully-featured hardware and software package that allows users to quickly start developing multi-motor control and other industrial applications:

- The **i.MX RT Industrial Drive Development Platform hardware package** consists of a daughter card integrating the i.MX RT1170 crossover MCU, a digital board to expand the interfaces available to the daughter card and a power stage board to transform control commands into power signals to drive a servo motor. All the boards can be configured and adapted to meet the specific requirements of the application that is being developed. This document provides an overview of the i.MX RT Industrial Drive Development Platform hardware package.
- The **i.MX RT Industrial Drive Development Platform software package** consists of a reference demo application and API that demonstrate how to take advantage of i.MX RT Industrial Drive Development Platform hardware capabilities to develop a secure, robust and reliable multi-motor control system which meets the requirements, standards and best practices required by industrial products. This significantly reduces the effort required to develop multi-motor control applications and the time-to-market of the product. More information on the software package can be found in *i.MX RT Industrial Drive Development Platform software overview* document.

1.1 Introducing the hardware package of i.MX RT Industrial Drive Development Platform

The i.MX RT Industrial Drive Development Platform hardware package leverages on a modular architecture consisting of a daughter card, a digital board and up to 4 power stage boards as illustrated in Figure 1:

- The ***daughter card*** (*ISI-QMC-DGC02*) is the core of the i.MX RT Industrial Drive Development Platform. It embeds an i.MX RT1176 dual-core crossover MCU featuring a 1 GHz (800 MHz in industrial qualified version) Arm Cortex-M7 core and a 400 MHz Arm Cortex-M4 core. The i.MX RT1176 crossover processor provides top-notch performance for industrial and multi-motor applications by supporting high-speed communication and peripheral interfaces, advanced graphics for industrial HMI, sensor interfaces and a wide range of security features.
- The ***digital board*** (*ISI-QMC-DB02*) works as an external platform to prototype multi-motor control applications. It includes widely used industrial communication and peripheral interfaces supported by the i.MX RT1170 crossover processor. It also provides the connectors that expose the control signals for the four motor devices.
- The ***power stage board*** (*ISI-QMC-PSB02 or ISI-QMC-PSB02B*) supports the control and connection of a 3-phase inverter, and comes with a built in motor connector gate driver and auxiliary components. Up to 4 power stage boards can be connected to the digital board to control up to 4 motors through the i.MX RT1170 crossover processor.
  Note: *the ISI-QMC-PSB02B version of the board DOES NOT include an analog frontend chip (NAFE11388). On the contrary, the ISI-QMC-PSB02 does integrate the analog frontend chip, but purchase is restricted. Please get in touch with your NXP representative if you are interested in purchasing ISI-QMC-PSB02.*

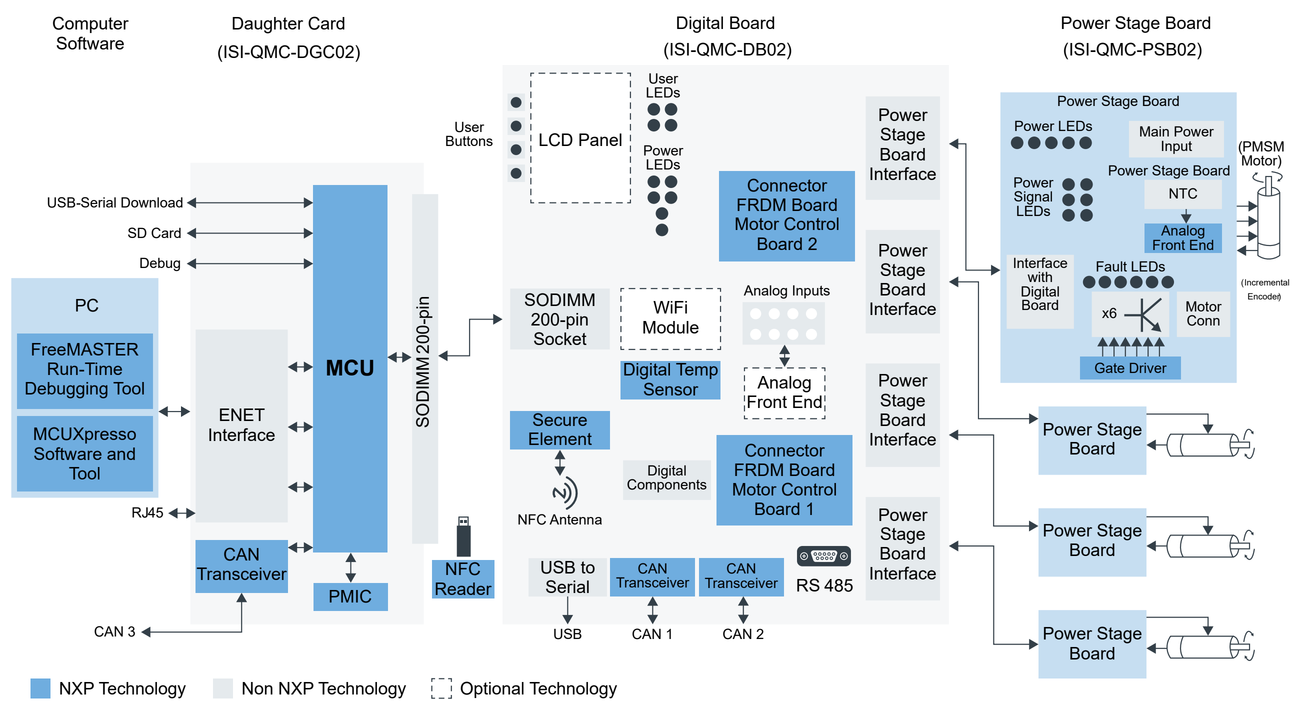

Figure 1. Hardware architecture of i.MX RT Industrial Drive Development Platform

Table 1. Hardware components of i.MX RT Industrial Drive Development Platform

Component	Part number
MCU	NXP i.MX RT1176
PMIC	NXP PF5020
Secure Element (SE)	NXP EdgeLock SE05x
Analog frontend	NXP NAFE 11388
CAN transceiver	NXPTJA115x (daughter card) NXP TJA146x (digital board)
Temperature sensor	NXP PCT2075
Gate driver	NXP GD3000
NFC reader	NXP PN7462

1.2 How to use this document

This document provides an overview of the i.MX RT Industrial Drive Development Platform hardware and is meant to be used as a starting point to understand its main components and functionalities. The document is structured as follows:

- Section 2 describes the **daughter card** and its main hardware components and configurations.
- Section 3 describes the **digital board** and its main hardware components and configurations.
- Section 4 describes the **power stage board** and its main hardware components and configurations.
- Section 5 briefly describes the **physical enclosure** that has been designed for i.MX RT Industrial Drive Development Platform. The enclosure cannot be purchased, but design files are provided.

This document is complementary to the **i.MX RT Industrial Drive Development Platform hardware design files** that you can download from the i.MX RT Industrial Drive Development Platform website. The design files provide detailed hardware schematics and layouts of the i.MX RT Industrial Drive Development Platform hardware components. They are meant to be used as a guidance to develop custom hardware solutions and to configure the hardware according to use-case specific requirements.

Note: *The i.MX RT Industrial Drive Development Platform hardware is highly customizable. This document only provides an overview of the main hardware functionalities and configurations. More advanced configurations might be available, but should only be applied after carefully reading the hardware design files. Please also notice that some configurations, if not applied correctly, might cause the hardware to malfunction or even break permanently.*

2 Daughter card hardware description

The ***daughter card*** is the core hardware component of the i.MX RT Industrial Drive Development Platform as it provides the application processor through which the whole system can be controlled. The daughter card is based on a single **i.MX RT1176 crossover MCU** that is able to control up to four motors simultaneously. The i.MX RT1176 crossover MCU is part of the i.MX RT117x family of products having the following characteristics:

- Arm Cortex-M7 core operating at 800 MHz (in industrial grade applications) with 32 kB L1 instruction cache and 32 kB L1 data cache
- Power efficient Arm Cortex-M4 core operating at 400 MHz with 16 kB instruction cache, 16 kB data cache, and 256 kB TCM
- Four Flex PWM interfaces
- Four Quad timers
- Six general programmable timer modules
- Two periodical interrupt timer modules
- Four quadrature decoders
- Four watchdog modules
- Four analog comparators
- Two 12-bit ADCs, which supports both differential and single-end inputs
- Junction temperature range of -40 ºC to 105 ºC

The i.MX RT1170 crossover MCU also provides various external memory interfaces, including SDRAM, SLC NAND FLASH, NOR/NAND FLASH, SD/eMMC and QUAD/OCTAL/HYPERBUS SPI with XIP capabilities. It also includes a wide range of other interfaces for connecting peripherals, such as WLAN, Ethernet TSN, Bluetooth™, GPS, camera sensors, and rich multimedia features, including a MIPI CSI/DSI interface, LCD display, graphic accelerator, SPDIF, and I2S audio interface. Please refer to the I.MX RT1170 product website for detailed information about the i.MX RT1170 crossover MCU.

The daughter card includes an **SODIMM 200 connector** (*edge connector*) to which the i.MX RT1170 crossover MCU communication and peripheral interfaces are routed. In order to facilitate motor-control applications, the edge connector has been designed so that analog signals and motor control signals (PWM, ENC, FAULT), and other communication signals (Ethernet, CAN, LCD etc.) are isolated. Moreover, high speed digital signals (ENET, MIPI, USB) are separated from low speed digital signals (motor control signal line PWM, ENC etc).

This section describes the main hardware components and interfaces provided by the daughter card. A more detailed description of the board and its hardware configurations is provided in the *daughter card hardware design files*.

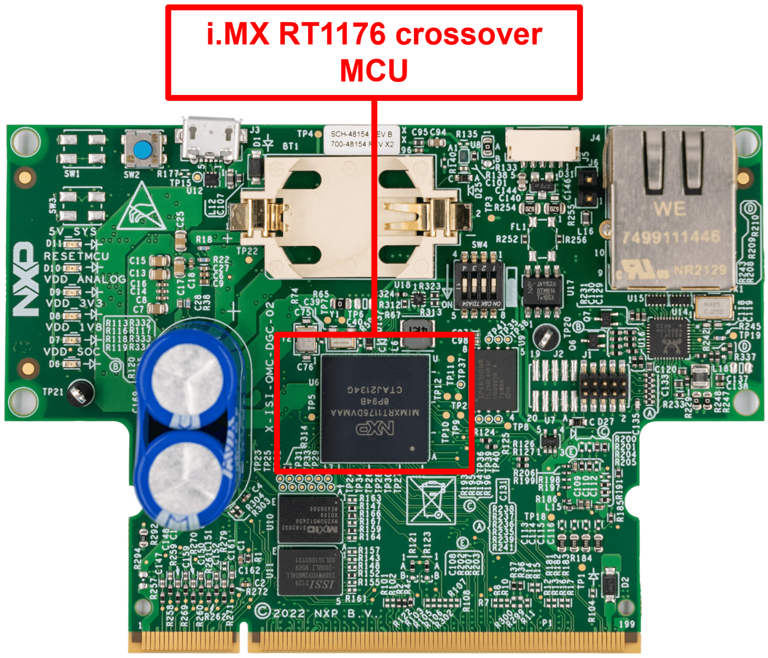

Figure 2. Daughter card i.MX RT1176 MCU

2.1 Power supply and power management unit

The daughter card 5V power supply voltage is provided either through the **micro USB connector** for standalone functionality or, most commonly, **through the edge connector** when the daughter card is connected to the digital board (see Section 3.1 for more information on how to supply power to the digital board). The NXP PF5020 PMIC, designed for high performance industrial applications, is used to manage and redistribute power on the daughter card.

To back up the power supply of the daughter card (for approximately 10 seconds), a **superCAP** has been integrated in the board. The presence of the superCAP allows the MCU, for example, to backup all required critical data into the external flash memory when main power supply is lost.

Finally, a **coin-cell battery** (*CR 2032*) is used to power the SNVS_LP (Low Power) of the i.MX RT1176 MCU for RTC backup. The battery must be inserted in the *BT1* coin cell battery holder included in the daughter card before the main power supply is applied, and superCAP is fully discharged.

Figure 3 shows the micro USB connector, the supercapacitor, the coin-cell battery holder and the edge connector.

Note: *The micro USB connector can also be used for serial download mode and allows the user to download the application (bootable) image without the need of a debug interface.*

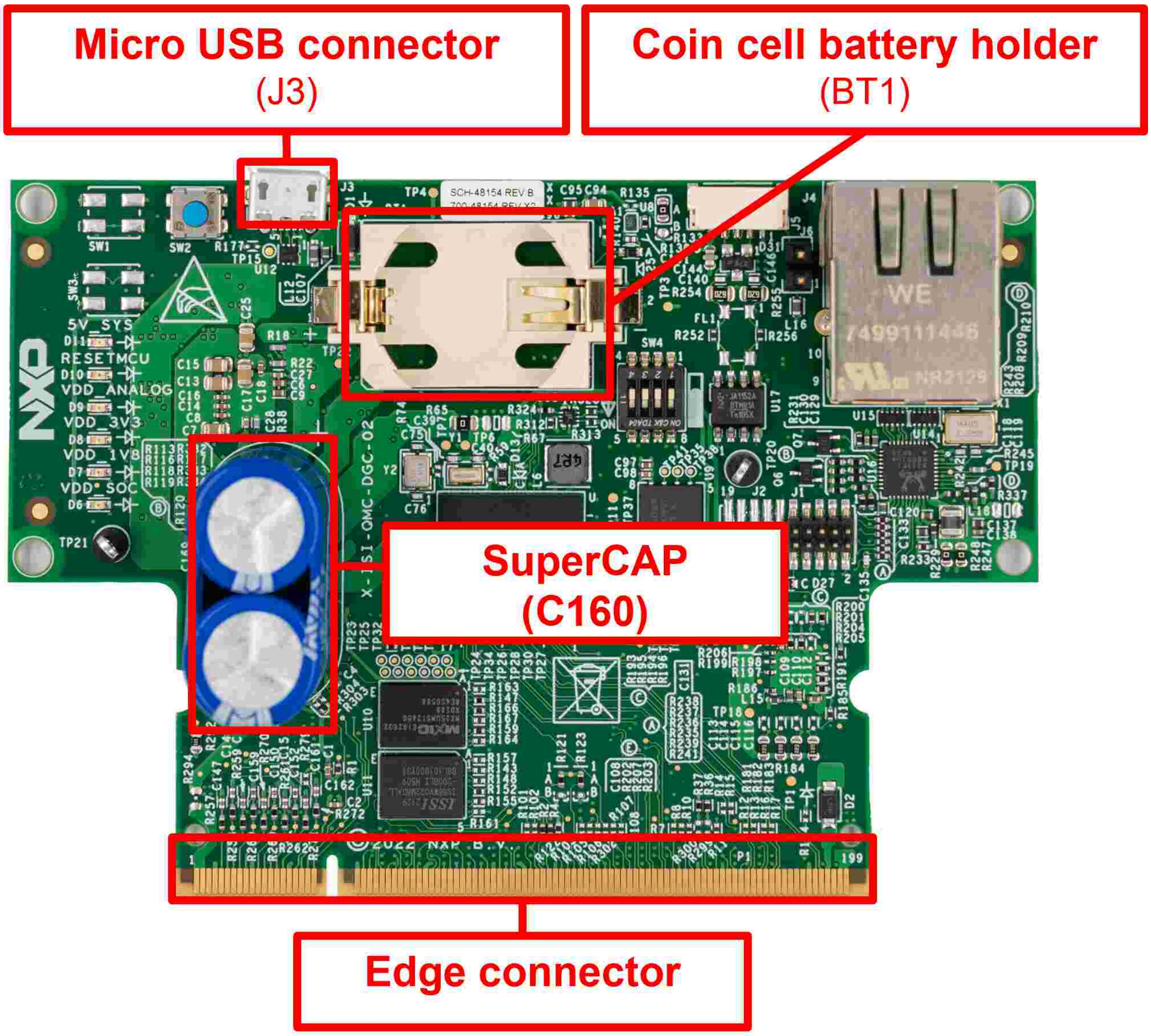

Figure 3. Daughter card power supply and power management unit

2.2 Status LEDs

The daughter card has six LEDs: 5 to indicate the status of the different board power domains as reported by NXP PF5020 PMIC (*D6, D7, D8, D9, D11*) and 1 to indicate power on reset (*D10*):

- **LED D6**: turns green when RT1170 SoC is correctly supplied (1.1V).
- **LED D7**: turns green when the board general 1.8V power supply is correctly identified.
- **LED D8**: turns green when the board general 3.3V power supply is correctly identified.
- **LED D9**: turns green when the 1.8V output LDO is active. It represents the analog power supply.
- **LED D10**: turns red when the daughter card is power reset.
- **LED D11**: turns green when the daughter card is correctly powered through the 5V onboard power supply.

The position of the status LEDs is shown in Figure 4.

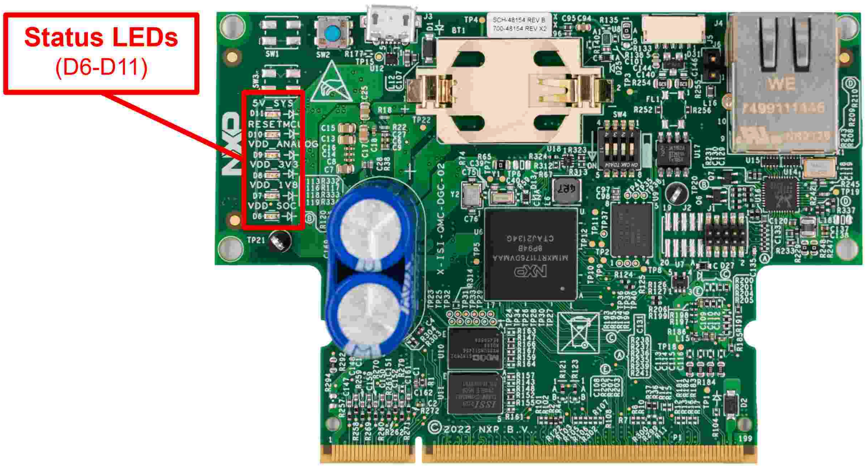

Figure 4. Daughter card status LEDs

2.3 External memories

The i.MX RT1176 crossover MCU provides various external memory interfaces, including SDRAM, SLC NAND FLASH, NOR/NAND FLASH, SD/eMMC, Quad/Octal SPI with XIP, and Hyper RAM/Flash. The daughter card includes the external memory interfaces shown in Figure 5 and listed below:

- An **SD card slot** (*CON1*) in the back side of the PCB. The SD card is primarily used to store the most recent firmware image and the most recently stored logged data file.
- A 512 Mbit **Octal Flash memory** (*U10*). The memory is powered by default at 1.8V and uses the *FlexSPI1* interface of the MCU. This is mainly used for storing logging data and configuration data.
- A 256 Mbit **Octal RAM memory** (*U11*). The memory is powered by default at 1.8V and uses the *FlexSPI1* interface of the MCU. It is primarily used for storing higher demanding data that is not critical from the time access point of view (e.g.; LCD frame buffers).
- A 256 Mbit **QSPI memory with XIP support** (*U9*). The memory is powered by default at 3.3V and uses the *FlexSPI2* interface of the MCU. This is the primary boot device.

Note: *The Octal Flash and Octal RAM memory share the same FlexSPI interface (FlexSPI1). Switching between devices is done through chip select signals (SS0 for Octal Flash and SS1 for Octal RAM).*

Note: *Octal Flash memory (U10) can be exchanged with other pin-to-pin compatible memories (e.g. HyperRAM / HyperFlash) in case the default configuration is not appropriate for your use case. Please refer to the daughter card hardware design files for more information.*

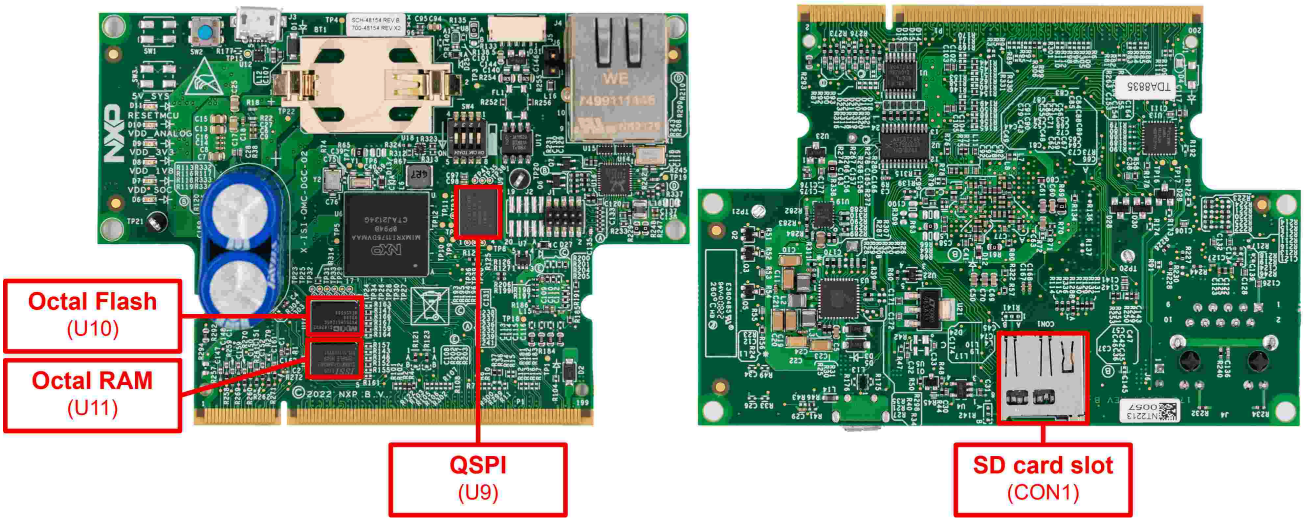

Figure 5. Daughter card external memories

2.4 Boot mode selection

The daughter card boot configuration can be selected using the **4 position DIP switch** (*SW4*) integrated in the board as shown in Figure 6.

- **Boot mode:** two boot modes are available: *internal boot* and *serial downloader*. *Internal boot* mode enables the ROM to execute the code directly from the boot device selected by boot configuration, while *serial downloader* mode provides a means to download a program image to the selected boot device over serial connection. Boot mode can be selected by setting the *SW4.1* and *SW4.2* switches as shown in Table 2.

Table 2. Boot mode selection

Mode	SW4.1	SW4.2
Serial downloader	On	Off
Internal boot	Off	On

- **FlexSPI instance selection**: if internal boot mode is set, then the *SW4.3* can be used to select the FlexSPI interface to use for boot (either *FlexSPI1* or *FlexSPI 2*) as shown in Table 3. In the default daughter card configuration the *FlexSPI1* interface is connected to Octal Flash memory, while the *FlexSPI2* interface is connected to the QSPI memory.
  Note: *Other boot configurations are available by configuring resistors R121 and R124 (boot from SD card). Please refer to the daughter card hardware design files for more information.*
  Note: *Octal Flash memory can be exchanged with other pin-to-pin compatible memories (e.g. HyperRAM / HyperFlash). In this case, it is possible to configure boot from these memories as well. Please refer to the daughter card hardware design files (schematics) for more information.*

Table 3. FlexSPI instance boot selection

Mode	SW4.3
Octal Flash (FlexSPI1)	Off
QSPI (FlexSPI2)	On

- **XIP enable**: the *SW4.4* switch determines if encrypted XIP is enabled or disabled for the selected boot configuration as shown in Table 4.

Table 4. XIP enable

Encrypted XIP	SW4.4
Enable	On
Disable	Off

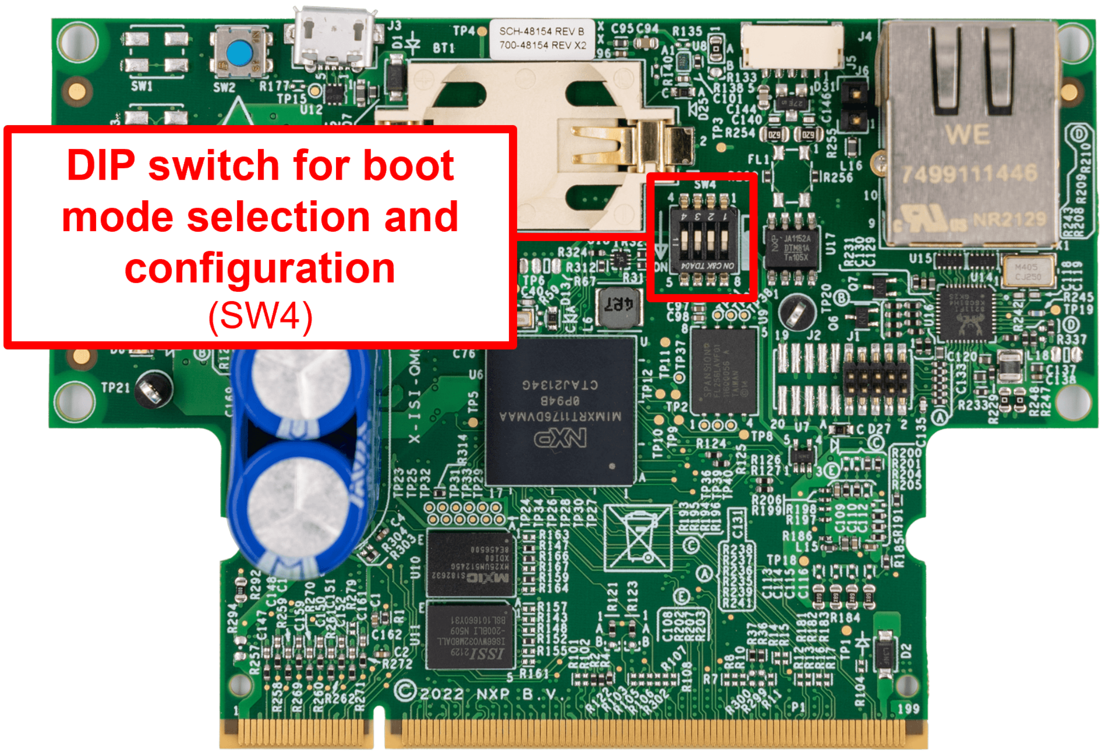

Figure 6. Daughter card boot mode selection

2.5 Buttons

The daughter card, by default, has a single onboard button (*SW2*) which acts as **POR (Power On Reset)**. Pressing it will cause a controlled reset of the whole daughter card board components through the *NXP PF5020 PMIC*.

Note: *The POR button can also be connected to MCU POR_B signal to initiate power on reset sequence only on MCU side instead of the whole board through PF5020.*

Two additional buttons, not placed by default, can be added to the board:

- The *SW1* button is the **ON/OFF button**. Pressing it will cause the daughter card to turn on or off.
- The *SW3* button is the **WAKEUP button**. When the MCU is in SNVS mode, pressing this button will wake up the MCU. This button is connected to SNVS GPIO so it can be reconfigured in software to act as USER button when in SNVS mode.

Figure 7 shows the *SW2* button and the placement for the optional *SW1* and *SW3* buttons.

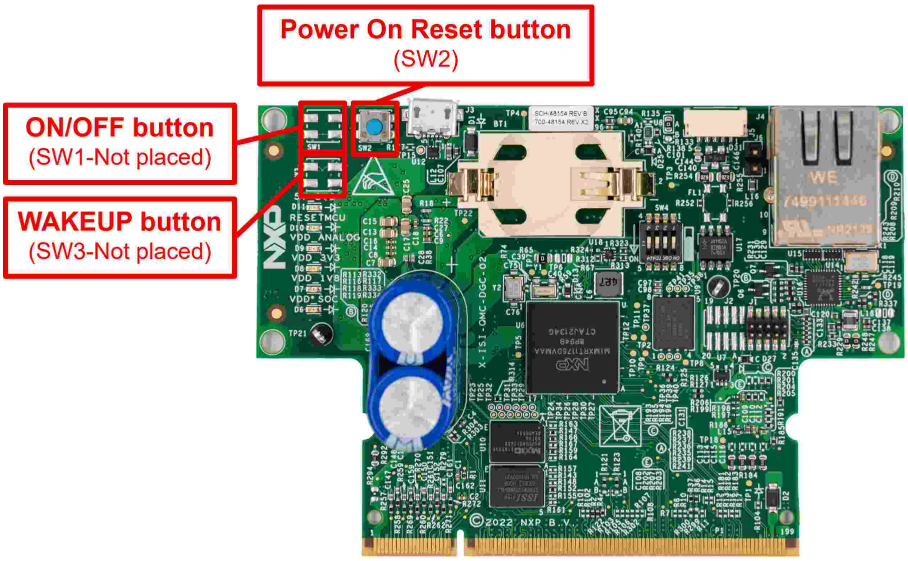

Figure 7. Daughter card buttons

2.6 TSN Ethernet and CAN interfaces

The daughter card provides a **1 Gbit Ethernet interface with TSN support** which can be accessed through the onboard **RJ45 Ethernet connector** (*J4*). This interface is primarily intended to access the TSN functionality. The RJ45 Ethernet connector has two status LEDs that indicate if the Ethernet link is active. The other Ethernet interfaces supported by the i.MX RT1170 MCU (a 100 Mbit Ethernet interface) are routed to the digital board through the edge connector of the daughter card.

The daughter card also provides a **secure High Speed CAN (HS-CAN) interface** enabled by NXP **TJA1152AT** transceiver (*U17*). The interface can be accessed through the integrated **5-pin Open-Style-Connector** (*J5*).

Figure 8 shows the RJ45 Ethernet connector, the HS-CAN transceiver and the HS-CAN 5-pin Open-Style-Connector in the daughter card.

Note: *The CAN interface is not used by the final application and will not be part of the FCC/CE qualification.*

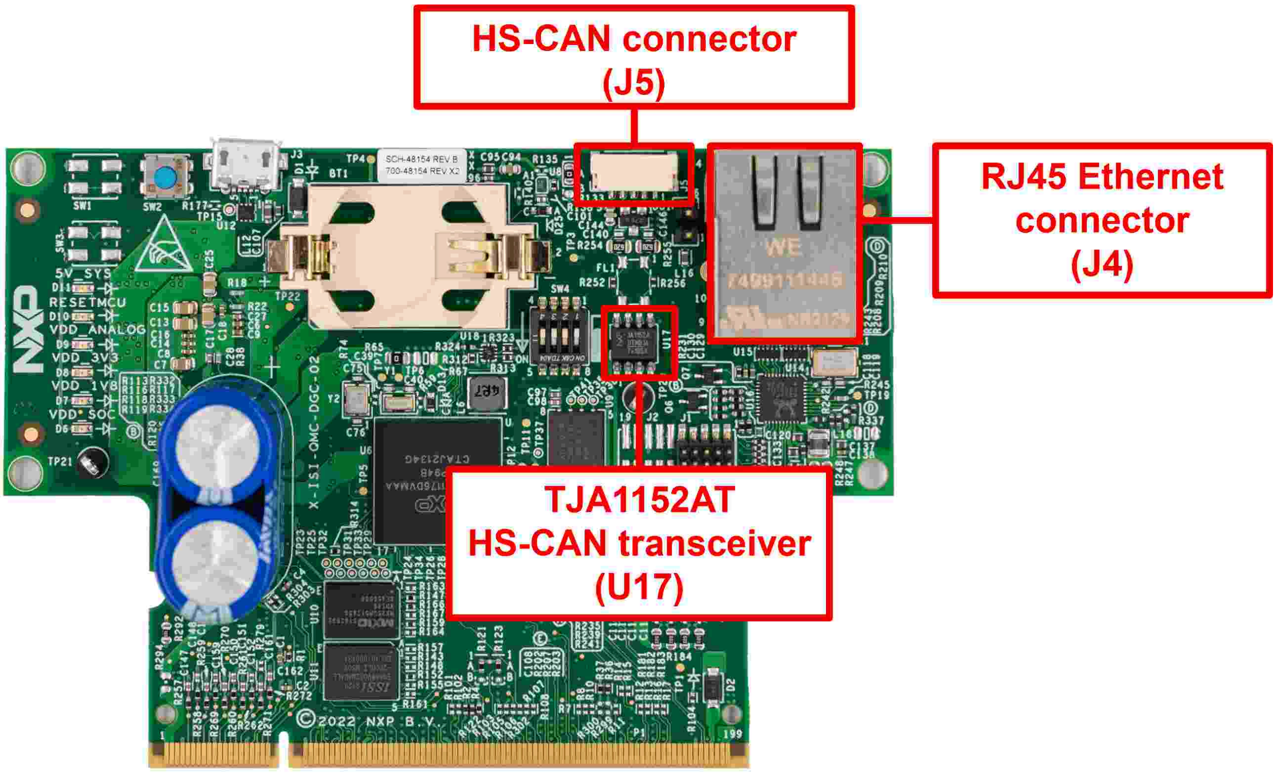

Figure 8. Daughter card TSN Ethernet connector

2.7 Debug interfaces

The daughter card provides the following software debug interfaces:

- **SWD:** this interface is available through the *J1* 10-pin connector. This is the default debug interface for the daughter card.
- **JTAG (without trace)**: this interface is not available by default since the *JTAG_TDI and JTAG_TDO* signals are not connected. To activate JTAG, solder 0 ohm resistors in *R89, R91*. You can then use the *J1* 10-pin connector to access JTAG functionality.
- **JTAG (with trace)**: this interface is not available by default. The JTAG trace functionality requires the user to solder an additional 10-pin connector in the space right next to the SWD connector (*J2*). In addition, it is required to solder 0 ohm resistors in *R89, R91, R103, R105, R107, R108, R110, R112* to connect the required JTAG signals.

Note: *Placing the R89, R91, R103, R105, R107, R108, R110, R112 resistors will replace some signals as shown in Figure 10. Make sure you don't need those signals before placing the resistors.*

Figure 9 shows the location of the daughter card SWD/JTAG connector and the position of the resistors required to activate JTAG signals.

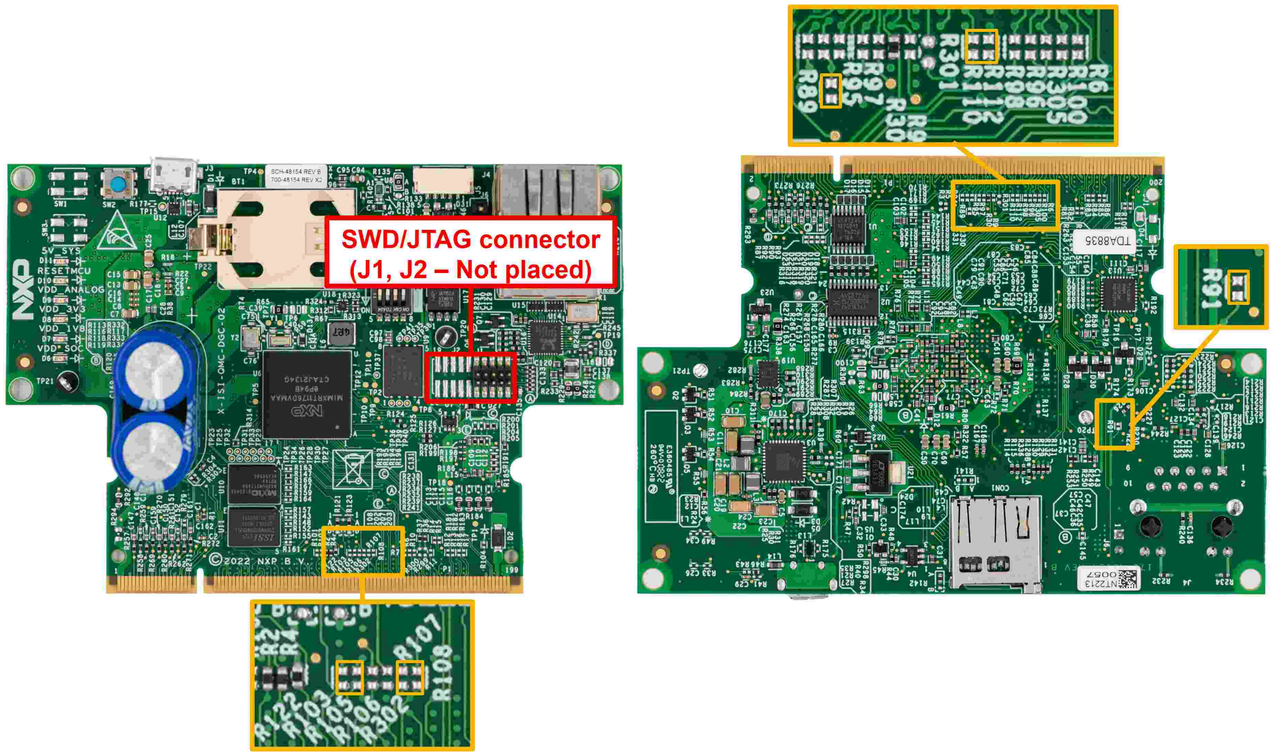

Figure 9. Daughter card SWD/JTAG connector

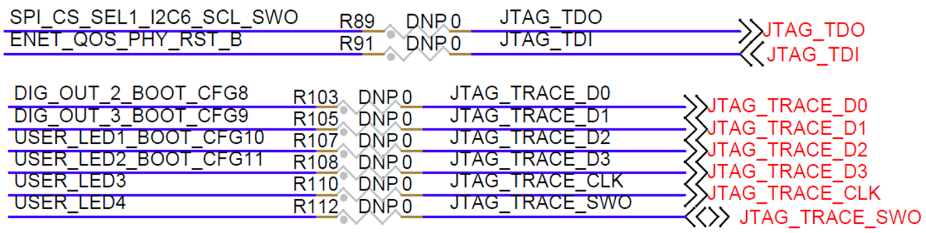

Figure 10. JTAG shared signals

2.8 Edge connector

The daughter card includes an **edge connector** to plug the card to the digital board. Through the edge connector, the interfaces and peripherals of i.MX RT1176 crossover MCU are routed to the digital board. This connector has been designed so that analog signals, motor control signals and other communication signals (Ethernet, CAN, LCD etc.) are isolated. Figure 11 shows the location of the edge connector on the daughter card PCB and the main signals routed to it.

Note: *Please refer to the daughter card hardware design files to know which signals are routed to the edge connector pins.*

Note: *In the i.MX RT Industrial Drive Development Platform demo application, SPI master emulated by FlexIO has a frequency of 2 MHz. If you set up higher frequencies for SPI master emulated by FlexIO, the recommendation is to not go beyond 12 MHz. Remember that if you go beyond 5 MHz you will not be able to communicate properly with GD3000. The affected pins are listed in Table 5.*

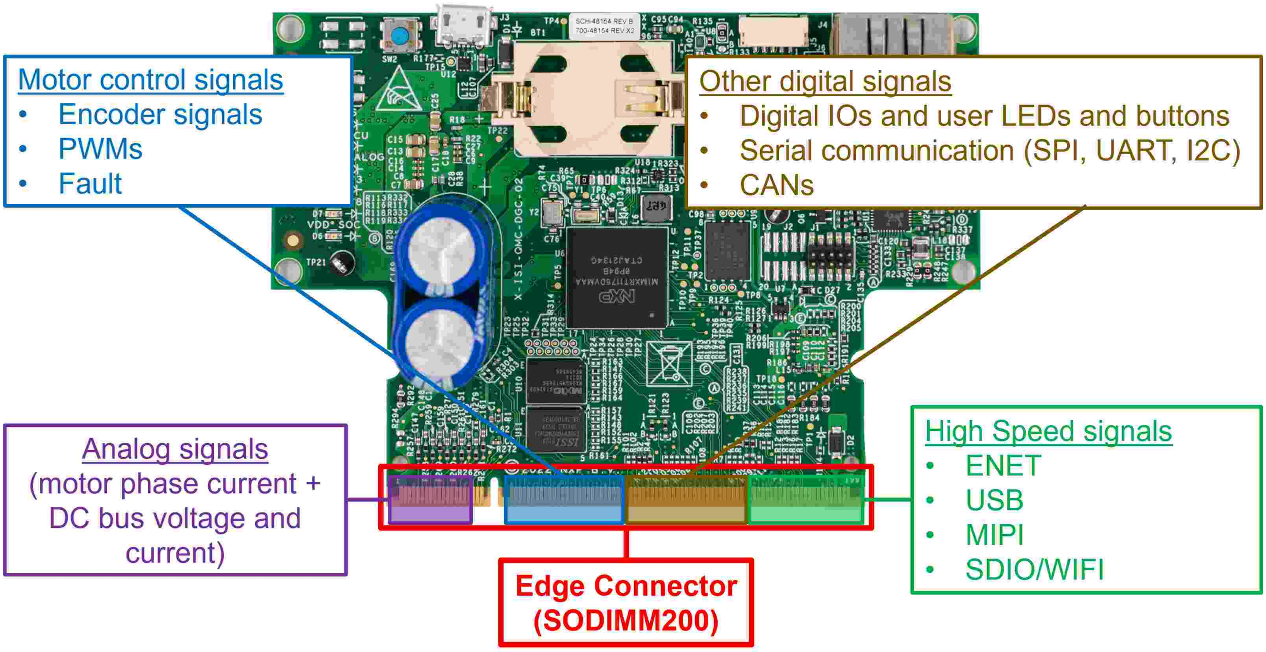

Figure 11. Daughter card edge connector

Table 5. SPI master emulated by FlexIO - affected pins

SPI interface	Pins
SPI1	SPI1_SCK_FXIO1_D15 SPI1_CS_FXIO1_D16 SPI1_MISO_FXIO1_D17 SPI1_MOSI_FXIO1_D18
SPI2	SPI2_SCK_FXIO1_D19 SPI2_CS_FXIO1_D20 SPI2_MISO_FXIO1_D21 SPI2_MOSI_FXIO1_D22
SPI3	SPI3_SCK_FXIO2_D04 SPI3_CS_FXIO2_D05 SPI3_MISO_FXIO2_D26 SPI3_MOSI_FXIO2_D27
SPI4	SPI4_SCK_FXIO2_D28 SPI4_CS_FXIO2_D29 SPI4_MISO_FXIO2_D30 SPI4_MOSI_FXIO2_D31

3 Digital board hardware description

The ***digital board*** is a platform designed to expand the interfaces available to the daughter card. It is optimized for flexibility, modularity and ease of use. The digital board provides a **SODIMM 200 socket** to connect a daughter card, such as the daughter card based on i.MX RT1176 crossover MCU described in this document.

The digital board integrates several communication interfaces (e.g. CAN, Ethernet, RS-485), security hardware (EdgeLock SE05x), analog and digital I/O interfaces and a rich user interface (e.g. LCD connectors, user buttons, LEDs). The digital board also includes connectors to drive 4 motor devices through power stage boards or 2 motor devices through FRDM-MC boards.

This section describes the main hardware components and interfaces provided by the digital board. A more detailed description of the board and its hardware configurations is provided in the *digital board hardware design files*.

3.1 Power supply and power management unit

The digital board must be supplied through a 5V source. A power switch (*SW1*) is used to turn power on or off. The power supply of the digital board can originate from either one of the following sources:

- If one or more power stage boards are used, the main power supply should come from the individual stages of the power stage boards. For this purpose either one of the connectors *J160, J162, J154, J5* can be used. Refer to Section 4.1 for more information.
  Note: *Make sure that at least one power connector is connected to a power stage board.*
- If you are using FRDM-MC-LVPMSM boards instead of the power stage boards, the digital board must be powered using the bulk connector (*J50*) while the FRDM-MC-LVPMSM boards must be supplied through the individual bulk connectors on the digital board (*J133 - FRDM1, J148 - FRDM4*). The cables required to connect the FRDM-MC-LVPMSM boards to the digital board are included in the i.MX RT Industrial Drive Development Platform hardware package.
- If the digital board is not connected to power stage boards or to FRDM-MC-LVPMSM boards, you can power the digital board using either the bulk connector (*J50*) or one of the two micro-USB connectors (*J48, J49*).

All onboard power supplies (PF5020 PMIC outputs) are enabled based on delayed inverted *PERI_PWR_ENABLE* signal from MCU. This is generated by the daughter card.

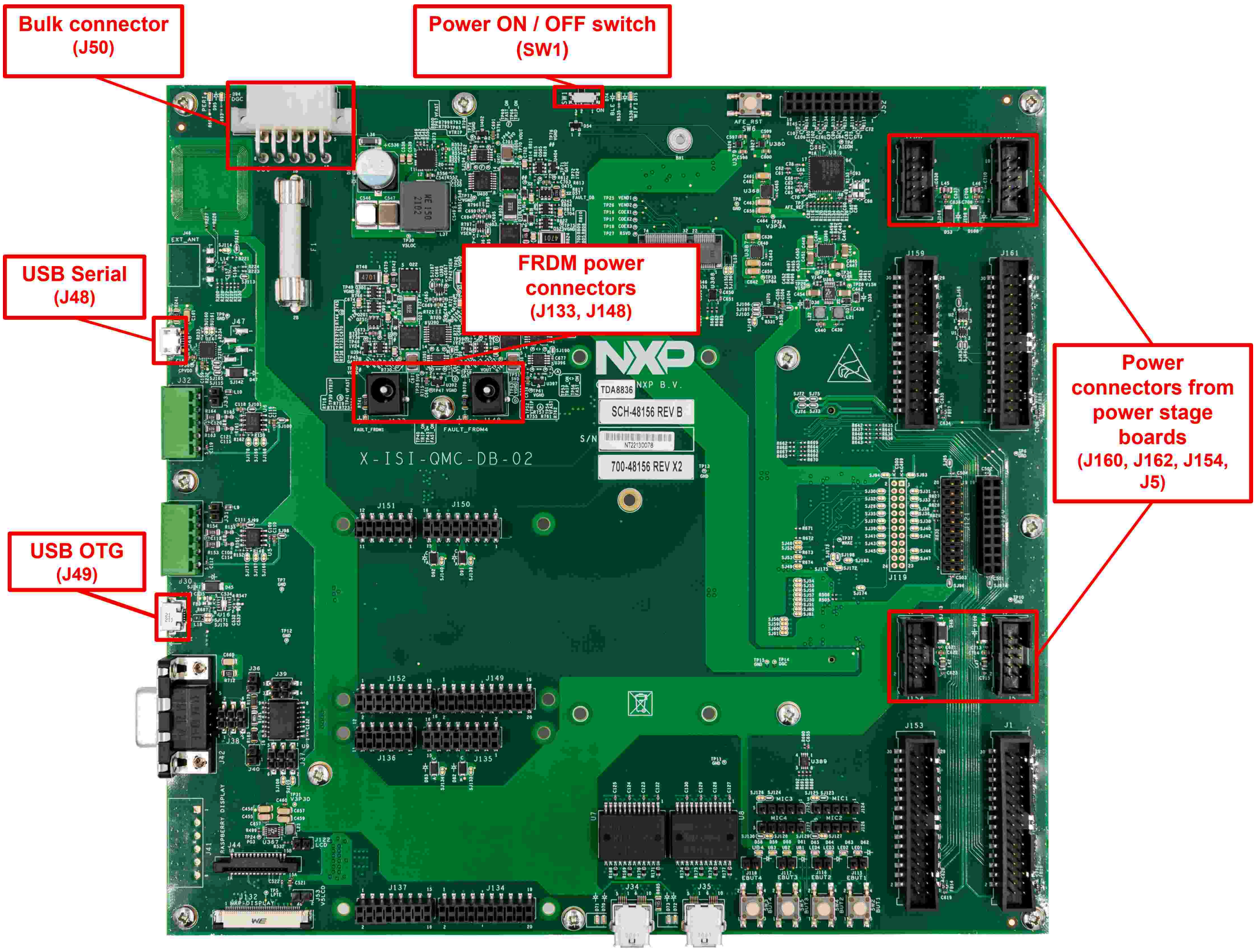

Figure 12. Digital board power supply interfaces

3.2 Daughter card connector (SO-DIMM 200)

The digital board features a **SO-DIMM 200 connector** through which the daughter card can be connected to the digital board. Through the SO-DIMM 200 connector, signals coming from the daughter card are routed to the digital board and vice versa. Please refer to the *digital board hardware design files* for a complete list of signals that are routed through the edge connector.

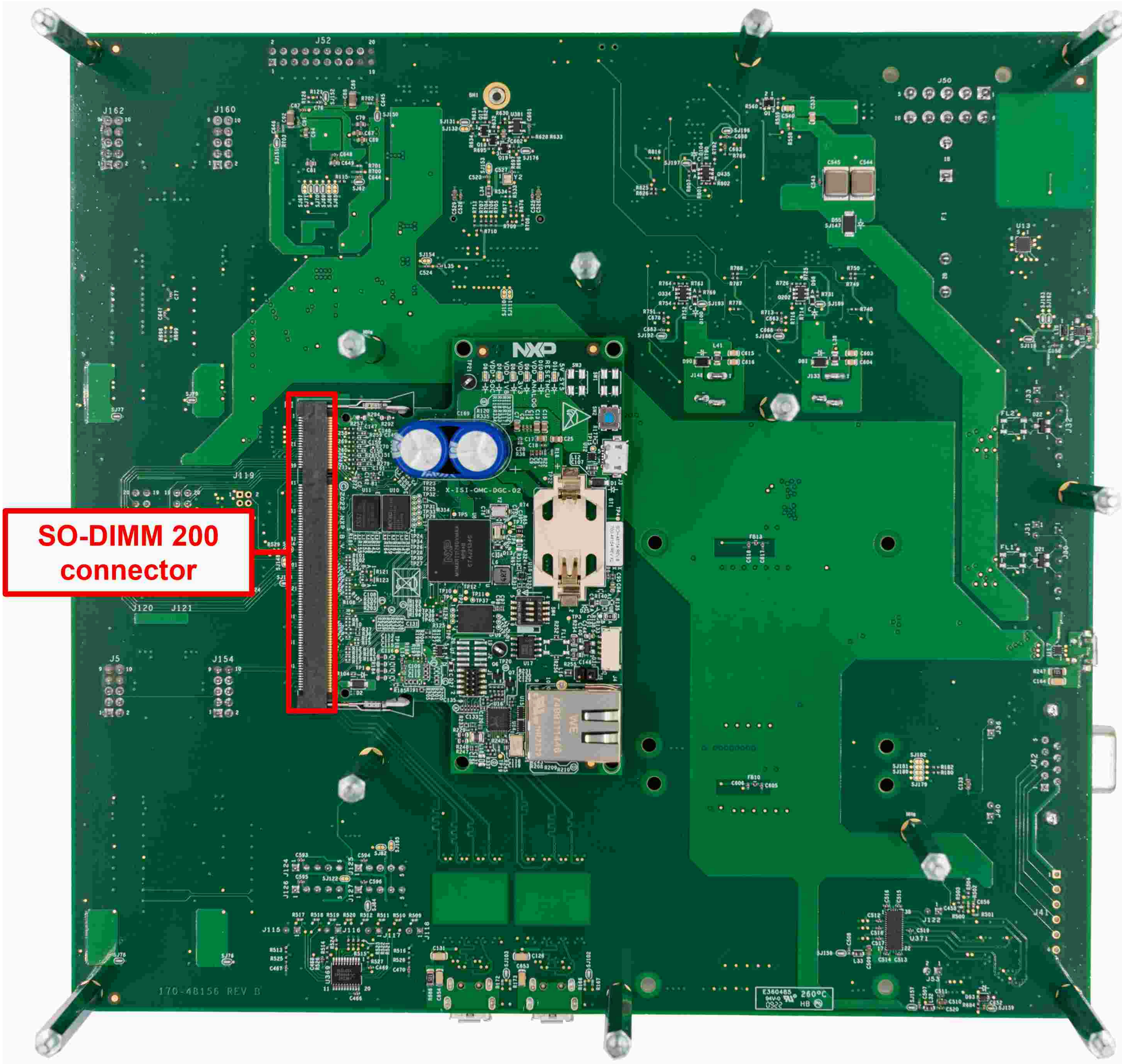

Figure 13. Digital board SO-DIMM 200 connector

3.3 Interconnection between digital board and power stage board

The digital board on-boards four 30-pin header connectors (*J159 - Motor 4, J153 - Motor 1, J161- Motor 2, J1 - Motor 3*) to connect to up to four power stage boards. Each 30-pin header connector exposes the 3-phase motor currents, DC-bus voltage, DC-bus current and fault signals from the motor device connected to it. The header also includes an interface for motor speed and position sensors control (PWMs, Encoder, fault signals) and SPI signals.

Figure 14 shows the placement of the four 30-pin header connectors in the digital board PCB and an overview of the signals available in each pin.

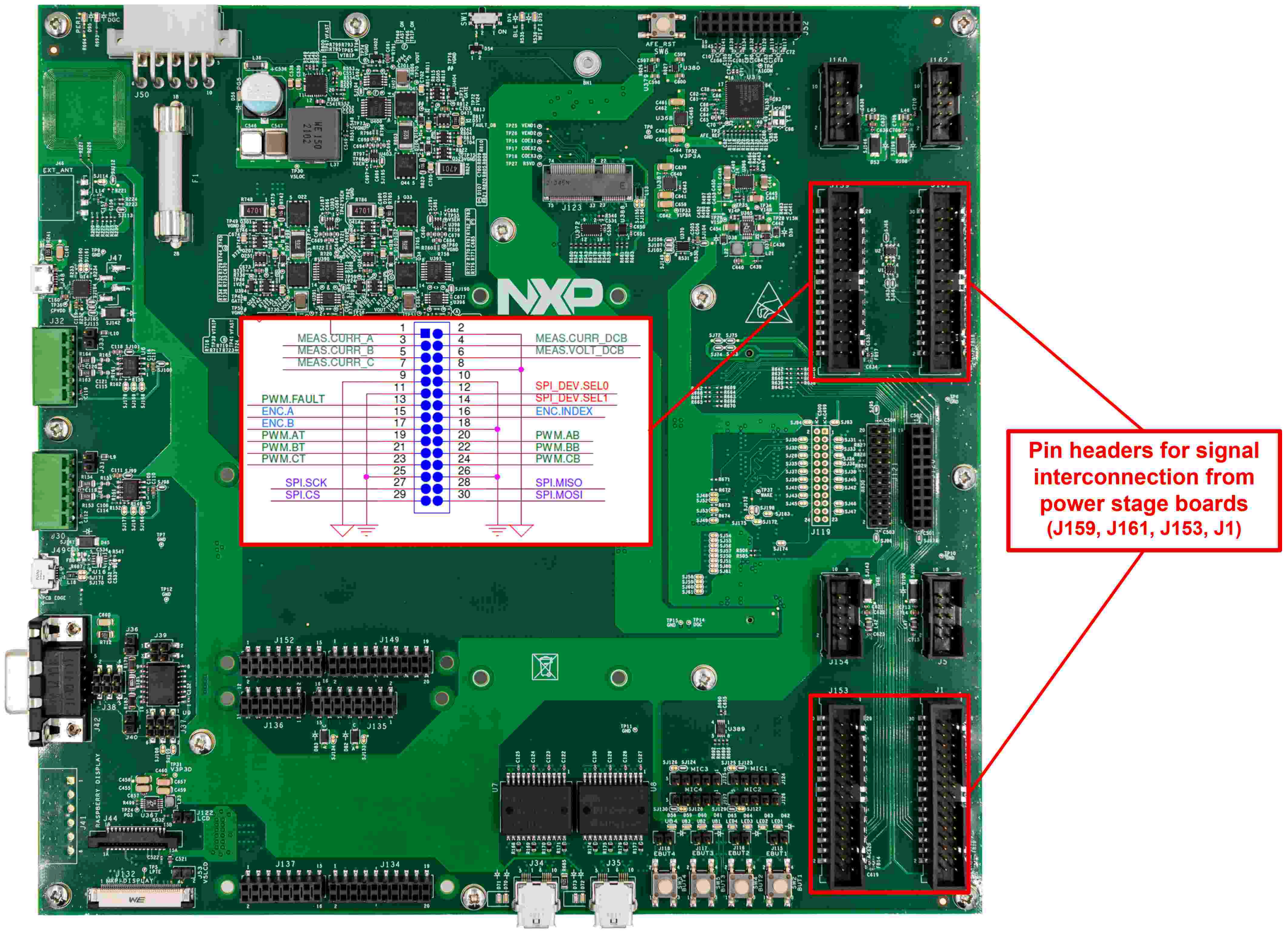

Figure 14. Signal interconnection interfaces between digital board and power stage boards

3.4 USB OTG and USB serial interfaces

The digital board provides **two USB interfaces** that can be accessed through a pair of **micro USB connectors**:

- A **USB to serial interface** (*J48*). It exposes two LPUART interfaces (LPUART6, LPUART8). LPUART6 is the primary serial interface for debug purposes, while LPUART8 is the secondary option (e.g. for additional debug). This USB interface also exposes an additional UART for serial download (*SER_DOWNLOAD*) that can be enabled by shorting *SJ160* and *SJ161*. The *J47* header can be soldered to access the RX and TX signals of LPUART6. The USB connector is a Type B connector.
- A **USB interface with OTG functionality** (*J49*). The OTG functionality is disabled by default and must be enabled as described in Table 7. The USB connector is a Type AB connector.

Both USB interfaces can be used to power the digital board as well (see Section 3.1). Figure 15 shows the placement of the two USB connectors.

Table 6. Activate serial download UART in J48 USB interface

Element	Position	Description
SJ160	Shorted	Enable *SER_DOWNLOAD.RXD*
SJ161	Shorted	Enable *SER_DOWNLOAD.TXD*

Table 7. Activate USB OTG in J49 USB interface

Element	Position	Description
SJ170	Shorted	Enable *OTG_DM*
SJ171	Shorted	Enable *OTG_DP*

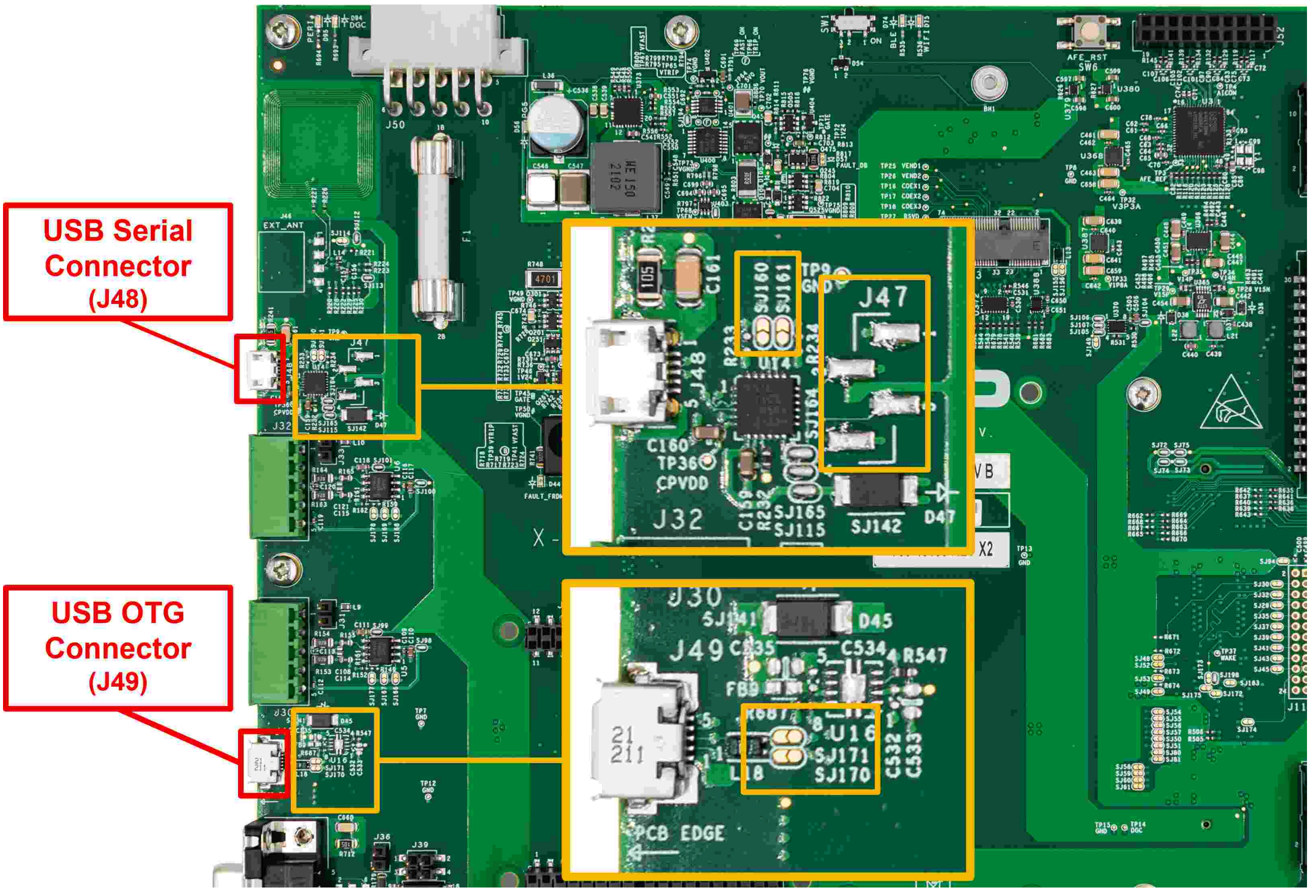

Figure 15. Digital board USB interfaces

3.5 Analog inputs & digital input/output

The digital board supports **8 analog single-ended inputs** (or optionally 4 differential inputs) through the *J52* female header connector. Analog signals are handled by the onboard analog frontend chip (*NAFE13388*). The *SW6* button can be used to reset the analog frontend.

Note: *The NAFE11388 is not populated by default. Before analog inputs can be used, the analog fronted chip must be soldered to the board.*

The digital board also supports **up to 8 digital inputs and up to 8 digital outputs**, respectively through *J121* female header connector and *J120* male header connector. Both connectors support up to 4 fast inputs/outputs connected to MCU GPIOs and up to 4 slow input/outputs connected to MCU SNVS GPIOs.

The analog and digital interfaces and connectors are shown in Figure 16.

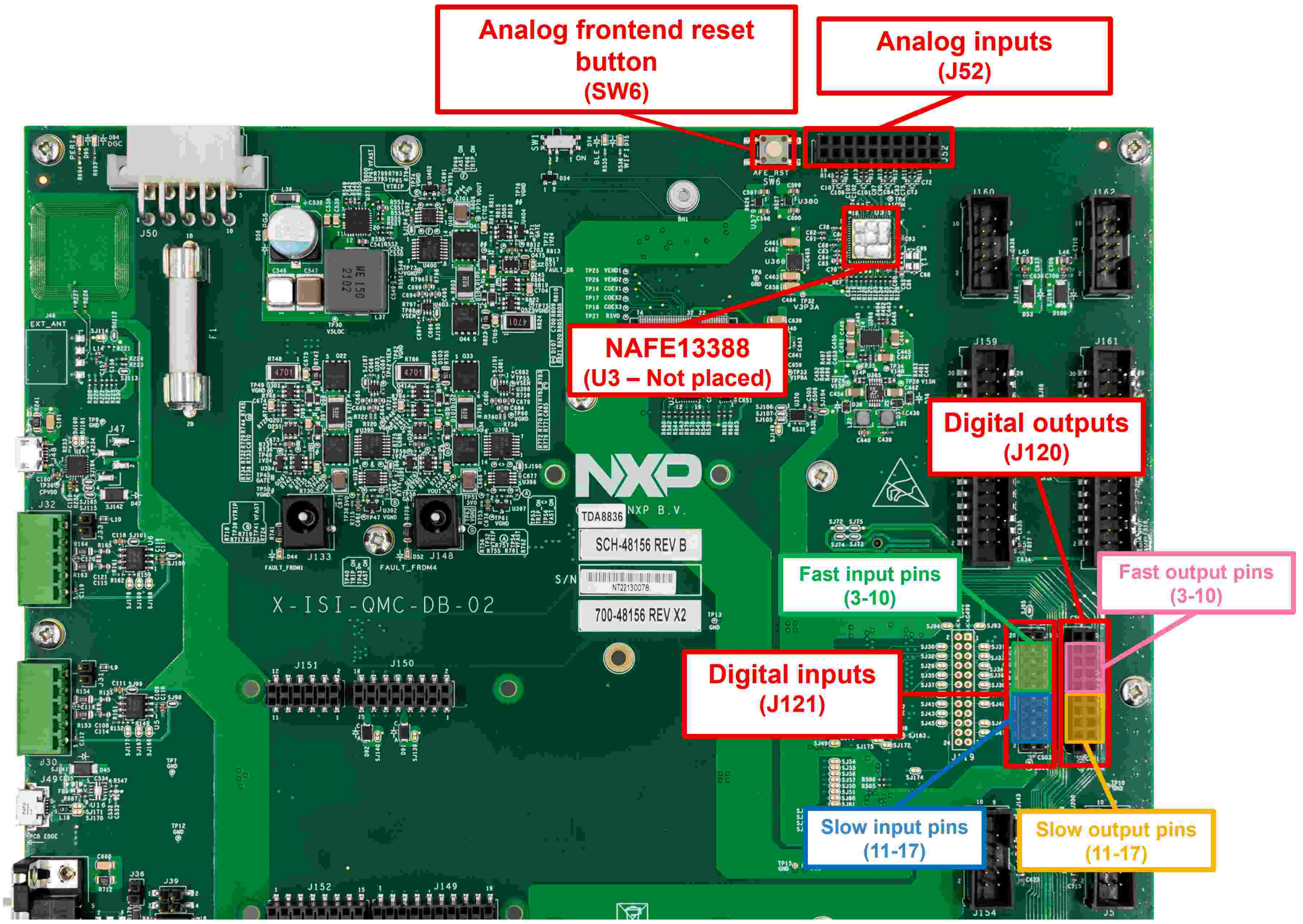

Figure 16. Analog input & digital input/output interfaces

3.6 Ethernet interface

The digital board provides **two Ethernet interfaces** which can be accessed through **industrial IX Type-B Ethernet connectors** (*J34, J35*). Two status LEDs for each interface are also provided (*D70* and *D71* for *J34* connector, *D72* and *D73* for *J35* connector). The i.MX RT Industrial Drive Development Platform hardware package includes two Ethernet cables IX to RJ45.

Note: *Even tough Ethernet signals are routed to the SODIMM connector; at the current stage these are not connected to i.MX RT1176 MCU. It is however possible to use J34 connector to access the Ethernet 10/100 Mbit interface by appropriately configuring 0R resistors in the daughter card. Please refer to the daughter card hardware design file for more information. Please also keep in mind that this will have an impact on other functionalities of the platform.*

Figure 17 shows the location of the Ethernet connectors in the digital board.

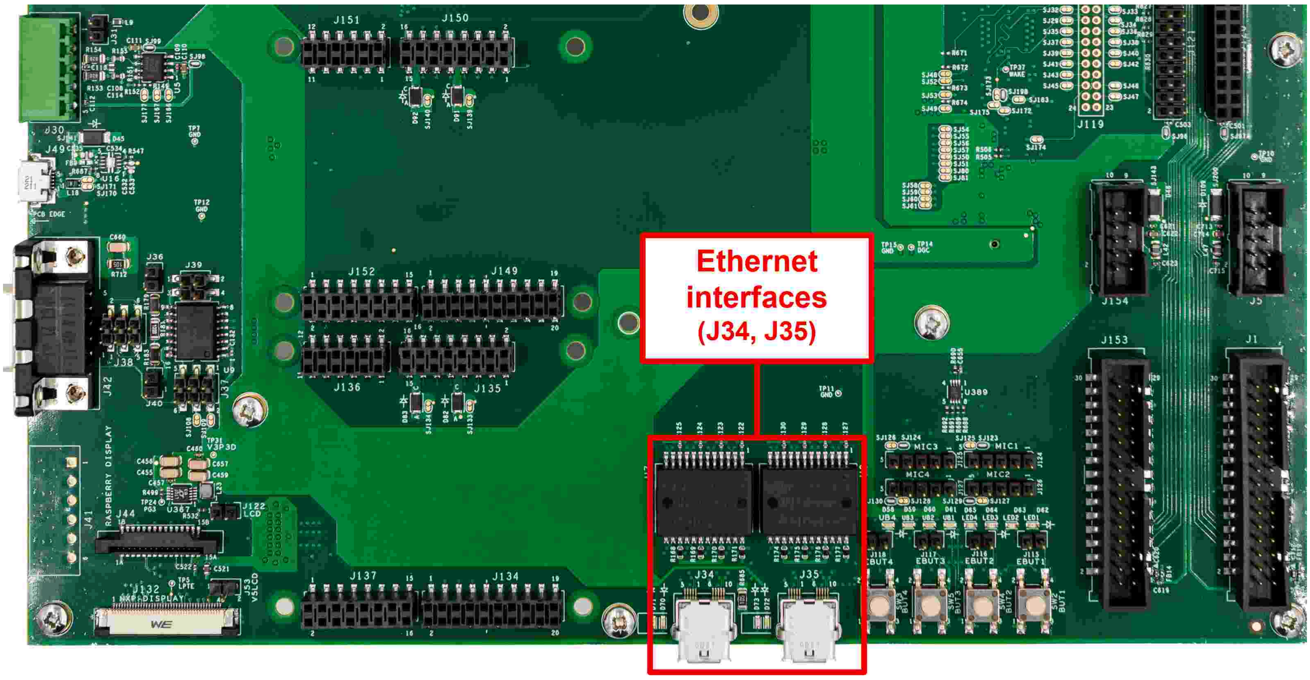

Figure 17. Digital board Ethernet interfaces

3.7 RS-485 interface

The digital board integrates one **RS-485 industrial interface** with DB9 connector (*J42*) for protocols which require RS-485, such as MODBUS or PROFIBUS. The RS-485 interface relies on the *ADM2484* RS-485 transceiver integrated in the digital board.

The digital board also provides jumpers to configure the power supply of the interface and the communication mode (half or full duplex):

- *J37* and *J39* jumpers are used to define the power supply settings for the *ADM2484* RS-485 transceiver.
- *J38* jumper is used to set RS-485 interface in half or full duplex communication mode.

Table 8 describes the *J37* and *J39* jumper configuration for the different power supply options for *ADM2484*. Similarly, Table 9 describes the *J38* jumper configuration to set the RS-485 interface in half duplex or full duplex mode.

The RS-485 interface is disabled by default. To activate it, configure the digital board as described in Table 10.

Figure 18 shows the location of the RS-485 interface and all the relevant jumpers and connectors.

Note: *The RS-485 interface is not used by the final application and will not be part of the FCC/CE qualification.*

Table 8. ADM2484 power settings

Power option	J37	J39
On-board 3.3V, not isolated	Jumper 1: 1-2	Jumper 1: 1-2 Jumper 2: 3-4
On-board 3.3V, not isolated Provides 3.3V to connector	Jumper 1: 1-2 Jumper 2: 5-6	Jumper 1: 1-2 Jumper 2: 3-4
On-board 5V, not isolated	Jumper 1: 3-4	Jumper 1: 1-2

Table 8. ADM2484 power settings*...continued*

Power option	J37	J39
		Jumper 2: 3-4
On-board 5V, not isolated Provides 5V to connector	Jumper 1: 3-4 Jumper 2: 5-6	Jumper 1: 1-2 Jumper 2: 3-4
External, isolated	Jumper 1: 5-6	Jumper 1: 3-4
External, not isolated	Jumper 1: 5-6	Jumper 1: 1-2 Jumper 2: 3-4

Table 9. RS-485 Half / Full duplex mode configuration

Mode	J38
Half-Duplex	Jumper 1: 3-5 Jumper 2: 4-6
Full-Duplex	Jumper 1: 1-3 Jumper 2: 2-4

Table 10. Activate RS-485 interface

Element	Position	Description
SJ108	Shorted	Enable 5V power supply to RS-485 interface
SJ109	Shorted	Enable 3.3V power supply to RS-485 interface
SJ179	Shorted	Enable RS485.RXD signal
SJ180	Shorted	Enable RS485.RE signal
SJ181	Shorted	Enable RS485.DE
SJ182	Shorted	Enable RS485.TXD

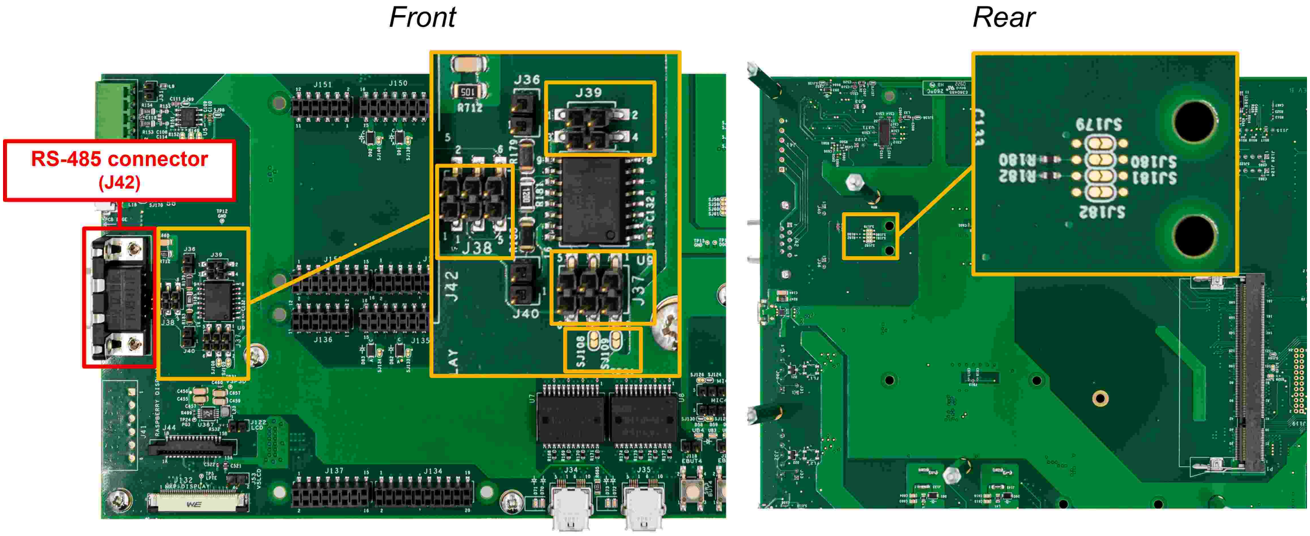

Figure 18. Digital board RS-485 interface

3.8 CAN interfaces

CAN is a robust vehicle bus standard designed to allow micro-controllers and devices to communicate with each other's applications without a host computer. The digital board integrates two industrial CAN interfaces with 5-pin open style connector (*J30, J32*) as shown in Section 3.8. The CAN transceiver is the *TJA1462AT* which supports **CAN high-speed** and **CAN FD**.

Both CAN interfaces are disabled by default. To enable the CAN interfaces, configure the digital board as described in Table 11.

Note: *The CAN interface is not used by the final application and will not be part of the FCC/CE qualification.*

Table 11. Activate CAN interfaces of digital board

Element	Position	Description
SJ166	Shorted	Enable CAN.TX for CAN 2 (*J30*)
SJ167	Shorted	Enable CAN.RX for CAN 2 (*J30*)
SJ177	Shorted	Enable CAN.STBY for CAN 2 (*J30*)
SJ168	Shorted	Enable CAN.TX for CAN 3 (*J32*)
SJ169	Shorted	Enable CAN.RX for CAN 3 (*J32*)
SJ178	Shorted	Enable CAN.STBY for CAN 3 (*J32*)

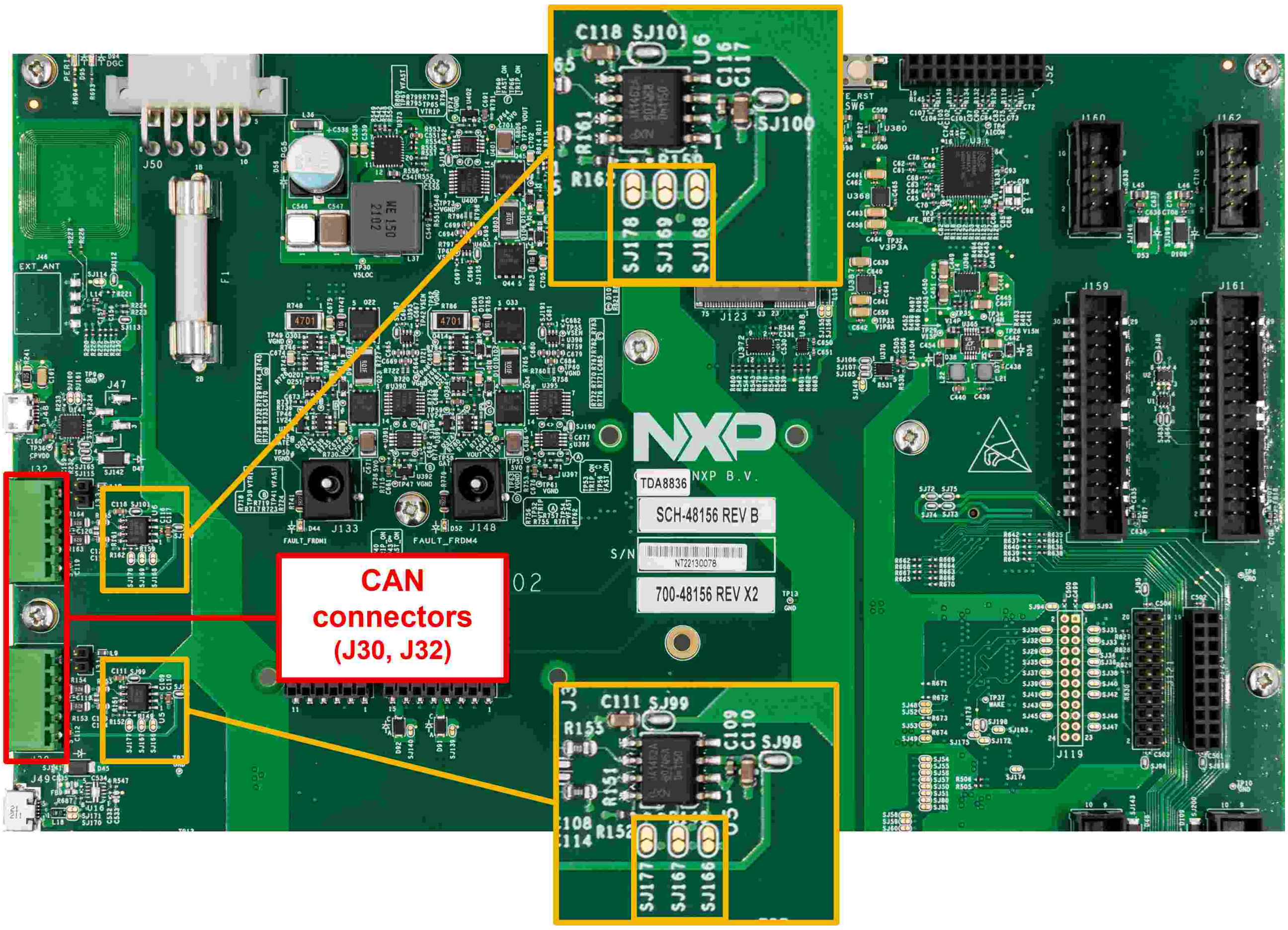

Figure 19. Digital board CAN connectors

3.9 Wireless module interface

The digital board provides an **M.2 connector** (*J123*) to plug-in a compatible Bluetooth module or WiFi module as shown in Figure 20. The interface is primarily designed for Embedded Artists 1DX M.2 module (not included in the i.MX RT Industrial Drive Development Platform hardware package).

The wireless module interface is disabled by default. To enable it, configure the digital board as shown in Table 12.

Note: *Two status LEDs are available (D74 and D75). D74 is used for indicating the status of the Bluetooth LE connection, while D75 is for the status of the WiFi connection. Embedded Artists 1DX module does not support LED status.*

Note: *Some Wi-Fi / Bluetooth LE signals are not routed by default to the M.2 connector. To activate those signals make sure to short the components shown in Figure 21. Please notice that activating those signals will replace other signals. Make sure to consult the digital board hardware design files before applying any change.*

Table 12. Activate Wireless module interface

Element	Position	Description
SJ153	Shorted	Enable 3.3V power supply to M.2 connector
SJ154	Shorted	Enable 1.8V power supply to M.2 connector

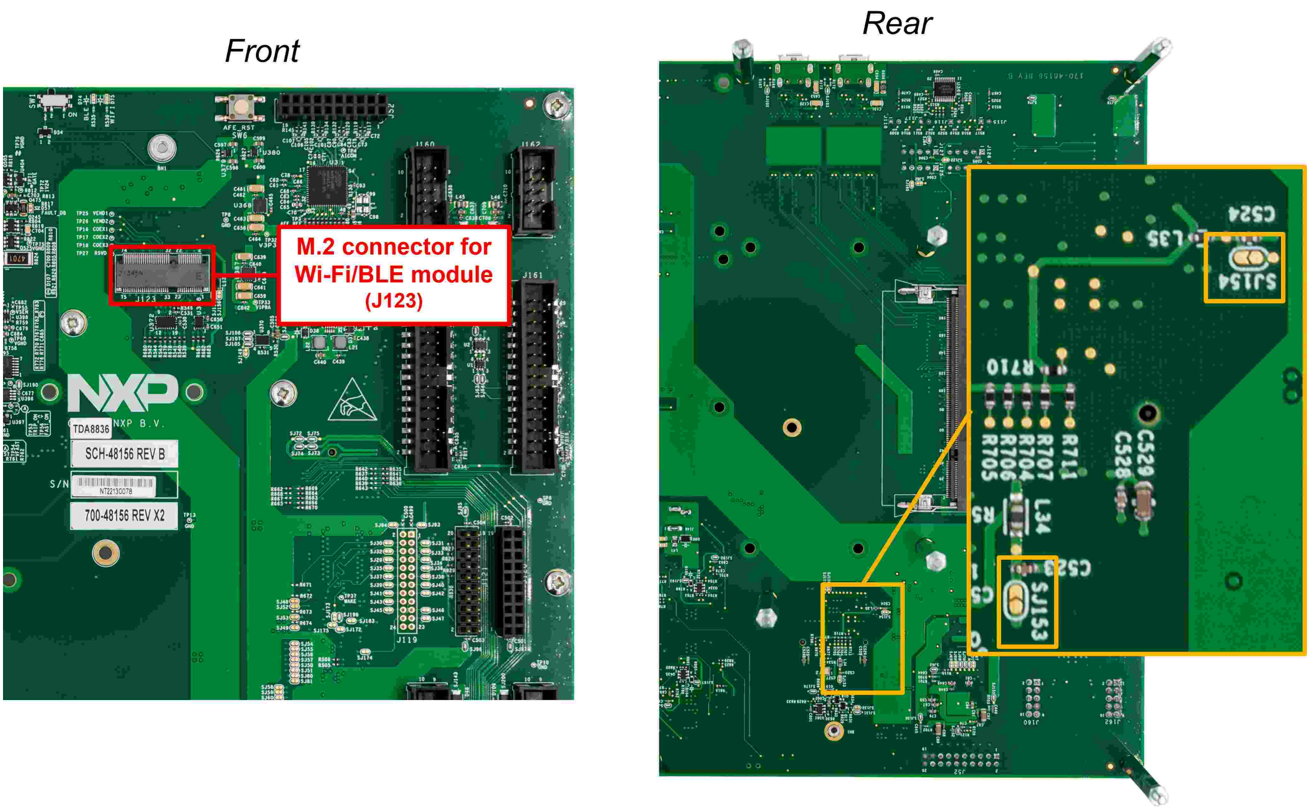

Figure 20. Digital board wireless module interface

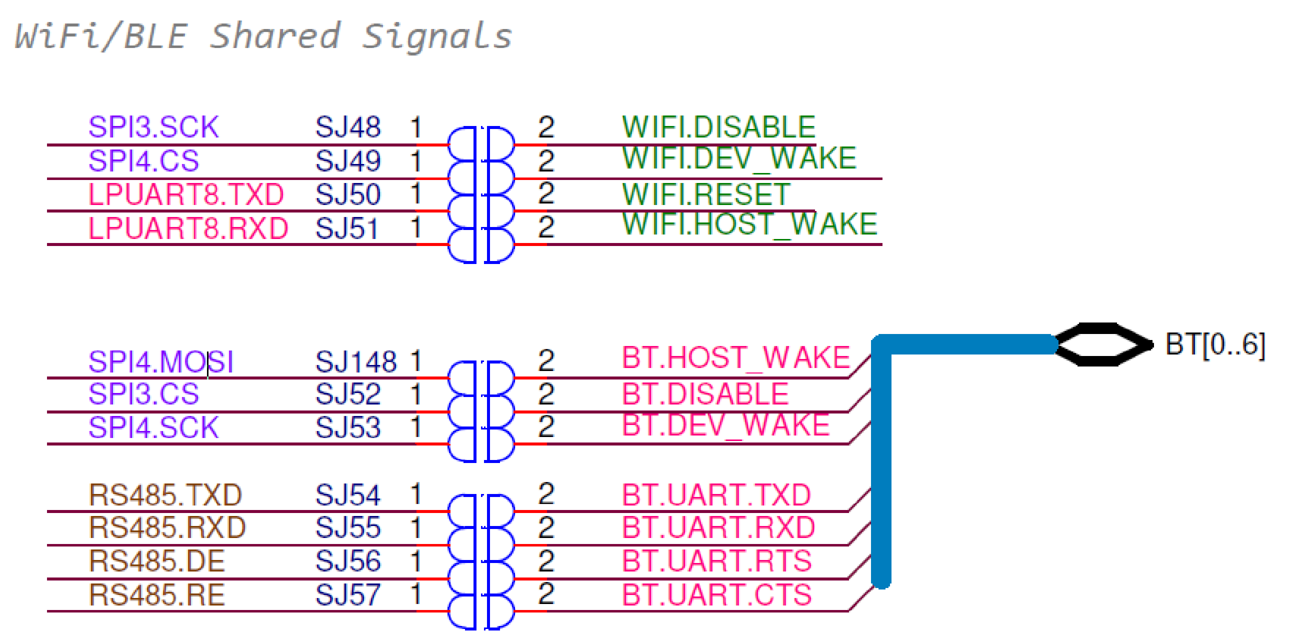

Figure 21. WiFi/Bluetooth LE shared signals

3.10 FlexIO interface

The digital board on-boards a **FlexIO footprint compatible with a FlexIO header** (24-pin, 2.54 mm pitch, female). The FlexIO interface is capable of supporting a wide range of protocols and peripherals including, but not limited to UART, I^2C, SPI, I2S, camera interface, display interface, PWM waveform generation and more. Figure 22 indicates the placement of the FlexIO footprint in the digital board.

The FlexIO interface is disabled by default. To activate it, configure the digital board as described in Table 13. Moreover, FlexIO interface signals must be routed to the daughter card by shorting the elements shown in Figure 23.

Note: *Notice that FlexIO signals will replace SPI1, SPI2, SPI3, SPI4, POR_B_3V3, MEAS3.VOLT_DCB and MEAS4.VOLT_DCB signals.*

Note: *Make sure to consult the hardware design files before making any modification to the hardware. Incorrect configurations may lead to conflicts and malfunctioning of the hardware.*

Table 13. Activate FlexIO interface

Element	Position	Description
SJ93	Shorted	Enable 5V power supply to FlexIO interface
SJ94	Shorted	Enable 3.3V power supply to FlexIO interface

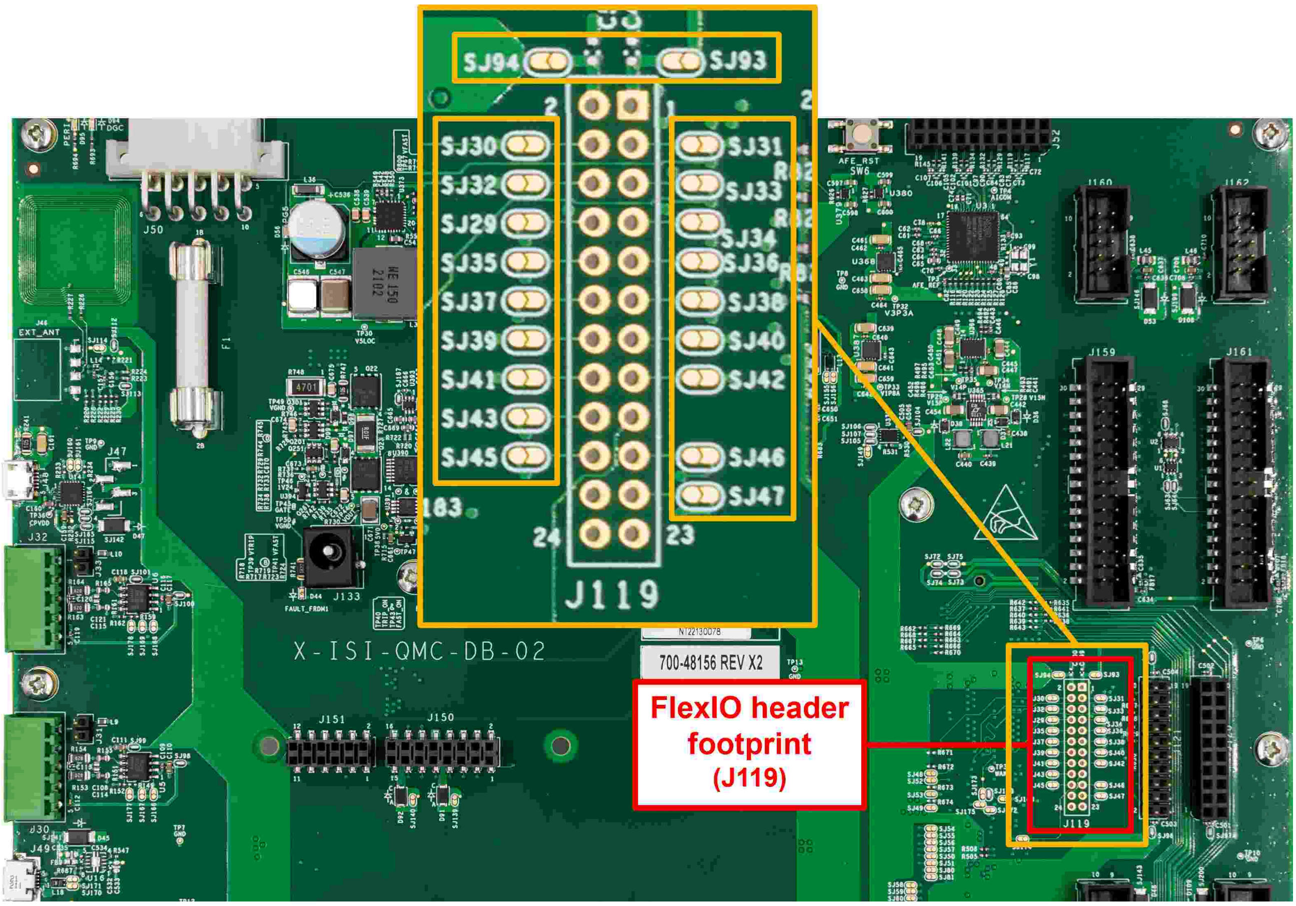

Figure 22. FlexIO interface footprint

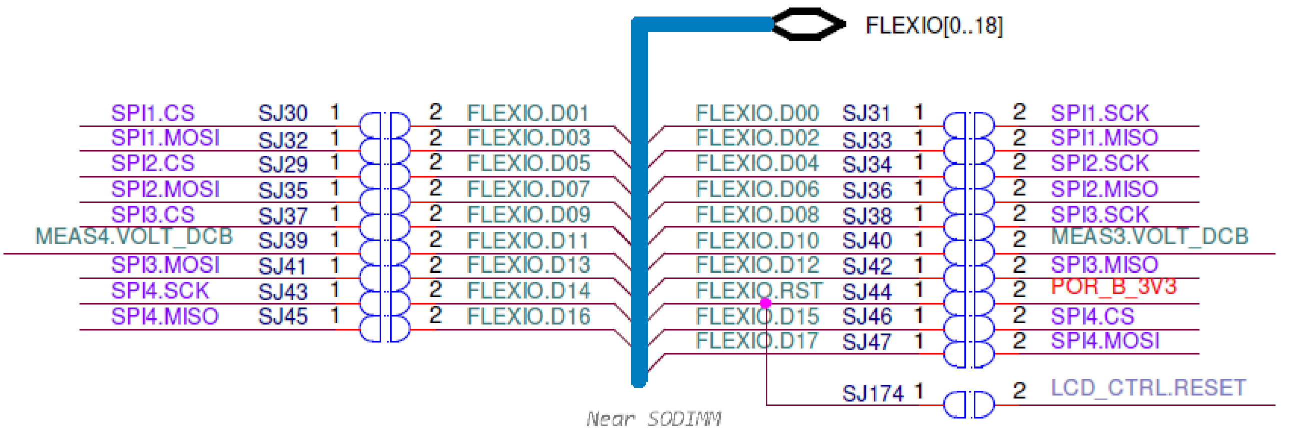

Figure 23. FlexIO interface shared signals

3.11 MIPI DSI interface for LCD

The digital board supports the connection of a **MIPI DSI LCD** that can be used as a user interface to display data and, if touch functionality is supported, as an input interface as well. Two MIPI DSI connectors (*J132* and *J44*) are provided to connect respectively the RK055HDMIPI4MA0 NXP LCD module or a Raspberry Pi compatible LCD. The *J53* jumper is used to connect the Raspberry Pi compatible LCD to the 5V external power supply.

- To enable the *J132* connector, the *J122* jumper should be in open position. This enables usage of RK055HDMIPI4MA0 NXP LCD module.
- To enable the *J44* connector, *J122* jumper should be in position 1-2. This enables usage of a Raspberry Pi compatible LCD.

Note: *The final application is only compatible with the RK055HDMIPI4MA0 NXP LCD module. Software support for other LCDs is not provided.*

The MIPI DSI interface and connectors are shown in Figure 24.

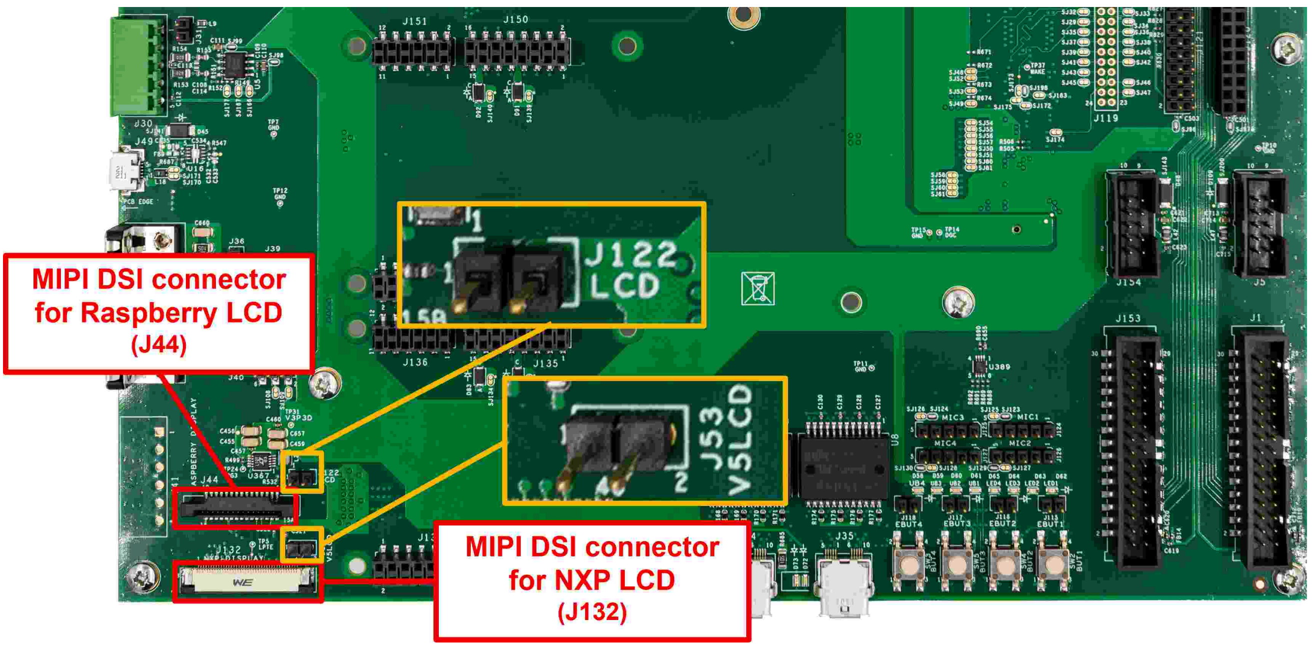

Figure 24. Digital board MIPI DSI interface and connectors

3.12 Temperature sensor

The digital board provides an on-board temperature sensor (*NXP PCT2075* - *U370*) featuring ±1 °C accuracy over -25 °C to +100 °C range. The sensor is controlled through an I^2C interface.

Note: *The PCT2075 temperature sensor includes an open-drain output (OS) which becomes active when the temperature exceeds the programmed limits. The OS signal must be activated by shorting SJ149. Please note that this replaces the SPI4.MISO signal routed to the edge connector.*

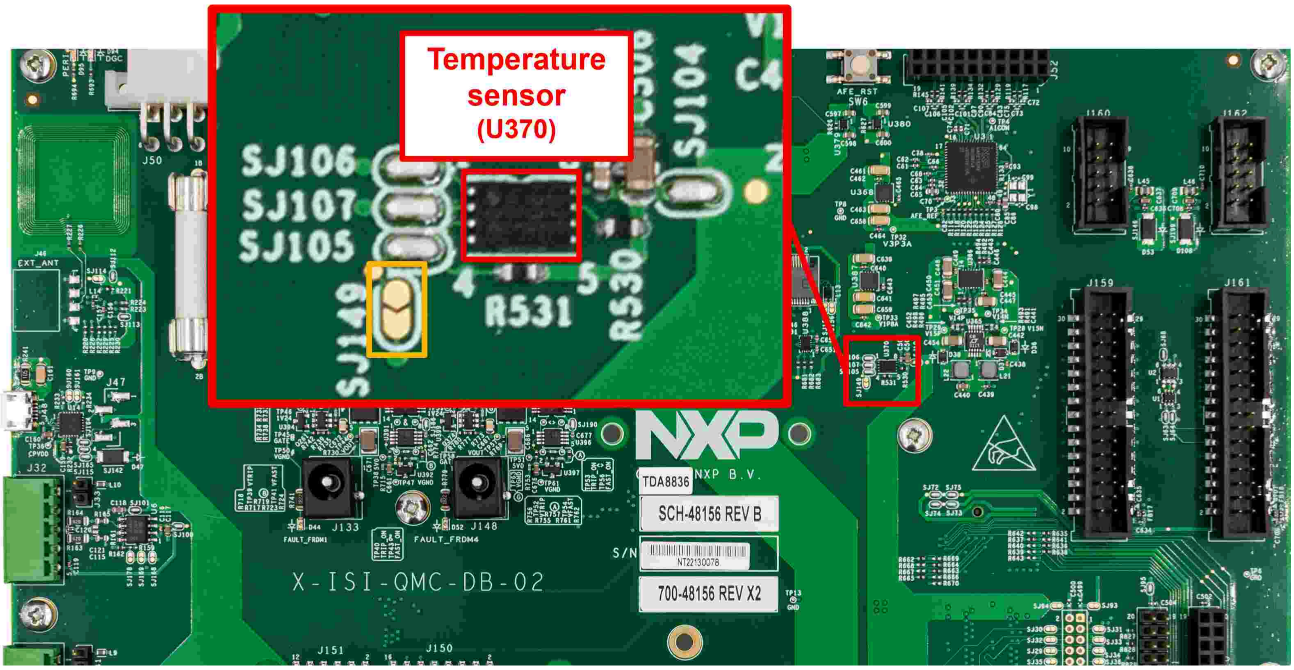

Figure 25. Digital board temperature sensor

3.13 FRDM-MC-LVPMSM Arduino interfaces

The digital board provides 2 separate Arduino headers, as shown in Figure 26, that can be used to connect up to 2 FRDM-MC-LVPMSM boards. The FRDM-MC-LVPMSM is a low-voltage, PMSM development platform that can be used to add motor control capabilities to your applications. FRDM-MC-LVPMSM boards can be used as an alternative to power stage boards to interface with motors.

Note: *Make sure that the boards are powered using the individual power connectors (J133, J148) integrated in the digital board. See Section 3.1 for more information.*

Note: *Do not stack FRDM-MC-LVPMSM boards on top of each others and do not use Arduino MCU boards.*

Note: *Do not use FRDM-MC-LVPMSM boards if power stage boards are used.*

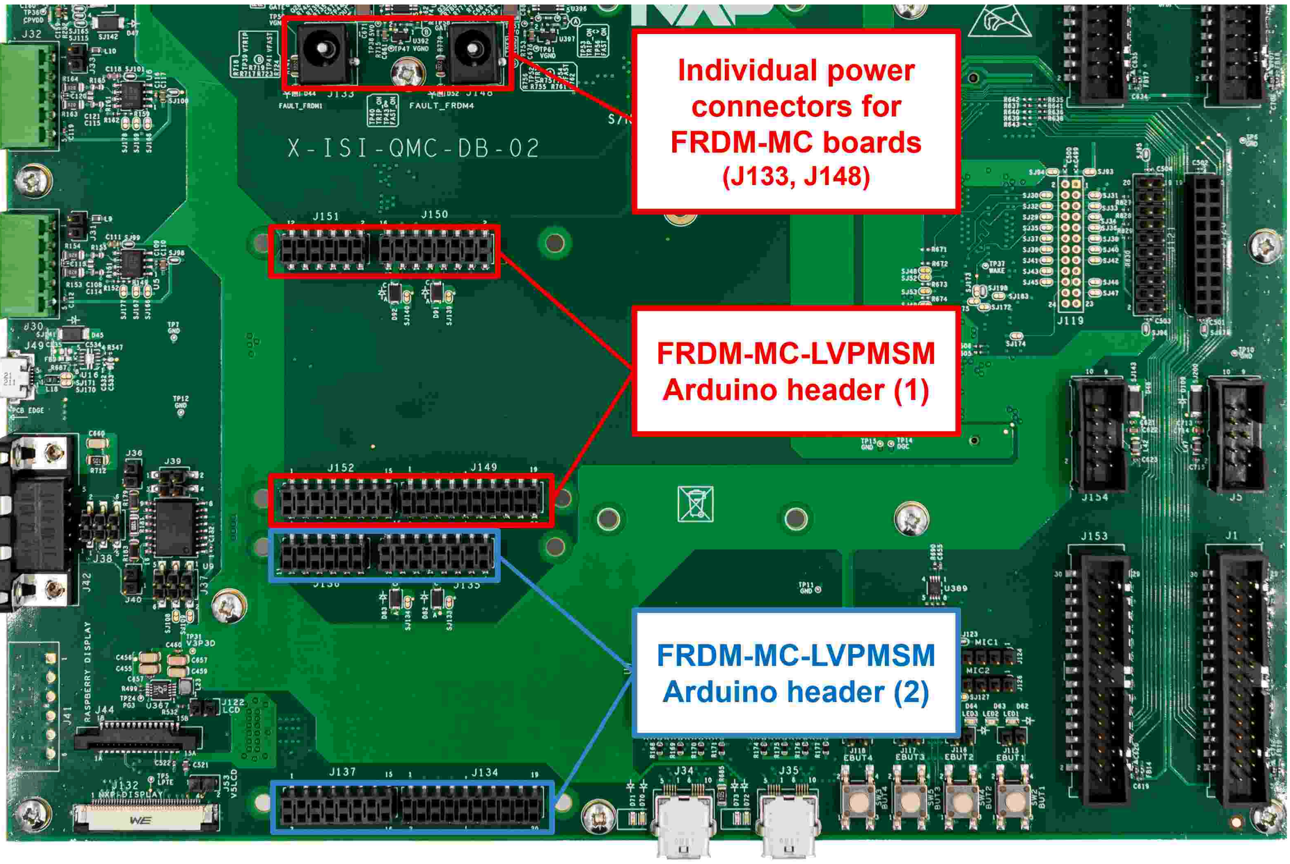

Figure 26. Digital board FRDM-MC Arduino headers and power connectors

3.14 Digital microphone interface

The digital board provides 4 pin headers to connect up to 4 digital microphones as shown in Figure 27. Digital microphones can be used to detect malfunctions in the operation of the device through anomaly detection algorithms. The pin headers are primarily designed to connect SwitchScience digital MEMS Microphone boards based on *Knowles SPH0641LU4H-1* digital microphone chip.

By default all digital microphone interfaces are disabled. To activate the digital microphone interfaces, configure the hardware as described in Table 14.

Table 14. Digital microphone interface configuration

Description	Configuration
Power DMIC interfaces	SJ122 shorted - DMIC interfaces are enabled SJ122 Open - DMIC interfaces are disabled (Default)
Select MIC1	SJ125 shorted, SJ123 open - MIC1 selected (Default) SJ125 open, SJ123 shorted - MIC1 not selected
Select MIC2	SJ127 shorted, SJ129 open - MIC2 selected SJ127 open, SJ129 shorted - MIC1 not selected (Default)
Select MIC3	SJ124 shorted, SJ126 open - MIC3 selected (Default) SJ124 open, SJ126 shorted - MIC1 not selected
Select MIC4	SJ128 shorted, SJ130 open - MIC4 selected

Table 14. Digital microphone interface configuration...*continued*

Description	Configuration
	SJ128 open, SJ130 shorted - MIC1 not selected (Default)

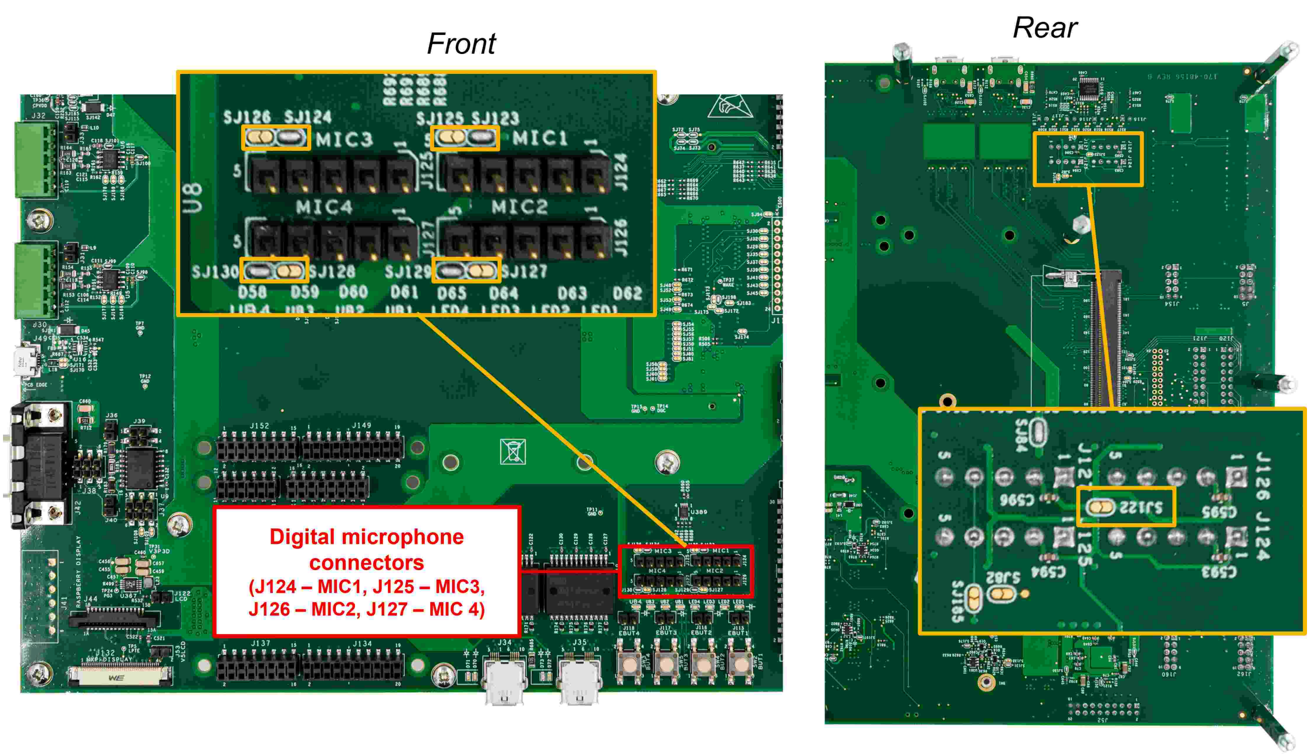

Figure 27. Digital board DMIC connectors

3.15 Secure element

The digital board integrates an **EdgeLock SE05x security IC** (variant *SE051C2HQ1/Z01XD*) designed to provide a secure, tamper-resistant platform to store mission-critical cryptographic keys and credentials. EdgeLock SE05x allows the MCU to perform cryptographic operations for security-critical communication and control functions in IoT security use cases, such as secure connection to public/private clouds, device-to-device authentication or sensor data protection, among many others.

In addition, EdgeLock SE05x supports a native contactless interface, providing a wireless interface to an external device like a smartphone or a handheld contactless reader. The digital board has an integrated NFC antenna, but it's also possible to connect a different external NFC antenna using the *J46* connector (not placed by default).

Figure 28 shows the placement of the EdgeLock SE05x security IC and the available interfaces and connectors for NFC antennas.

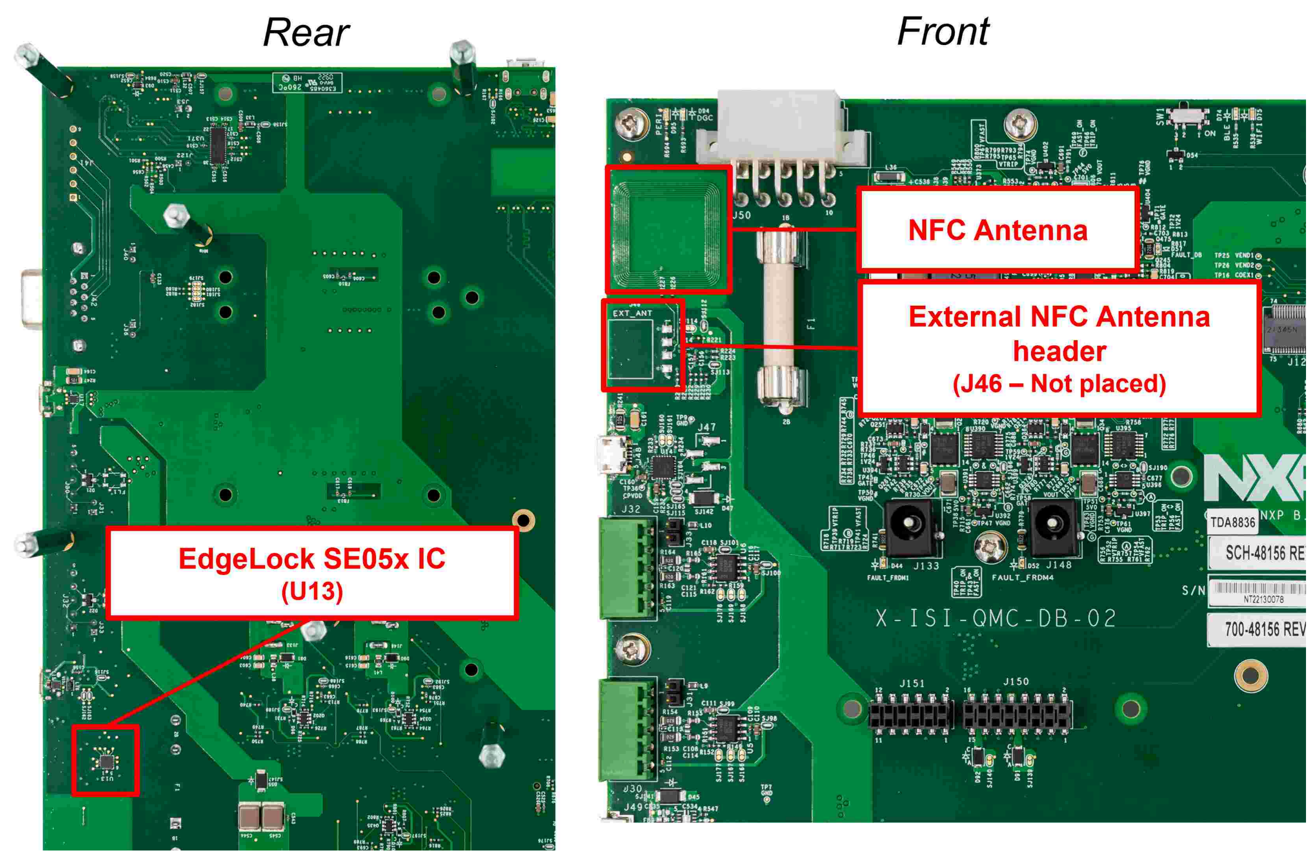

Figure 28. Digital board EdgeLock SE05x SE

3.16 User buttons and LEDs

The digital board provides the following user interfaces that enable direct human interaction with the board:

- **User buttons**: the digital board provides 4 buttons (*SW2, SW3, SW4, SW5*) whose behavior can be defined by the application. Jumper connectors (*J115, J116, J117, J118*) are provided to connect external buttons to the digital board.
- **Button LEDs**: 4 green LEDs (*D58, D59, D60, D61*) are provided to give an instant feedback when a user button is pressed. As a result, LED *D61* turns on when user button 1 (*SW2*) is pressed, LED D60 when user button 2 (*SW4*) is pressed, LED *D59* when user button 3 (*SW5*) is pressed and LED *D58* when user button 4 is pressed (*SW3*)
- **User LEDs**: 4 yellow LEDs (*D62, D63, D64, D65*) whose function and behavior can be defined by the application. LEDs can be turned on by turning HIGH the respective signals.

The user buttons and LEDs in the digital board are shown in Figure 29. Schematics are shown in Figure 30.

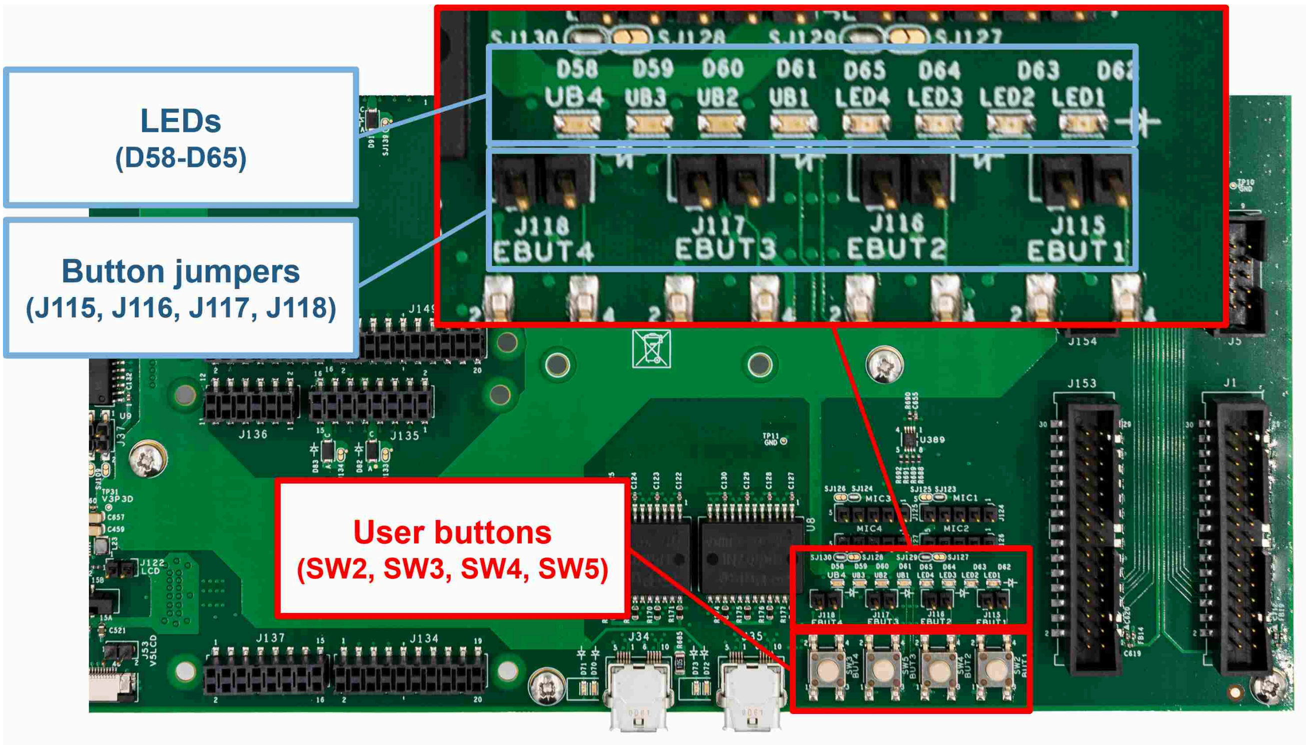

Figure 29. Digital board user buttons and LEDs

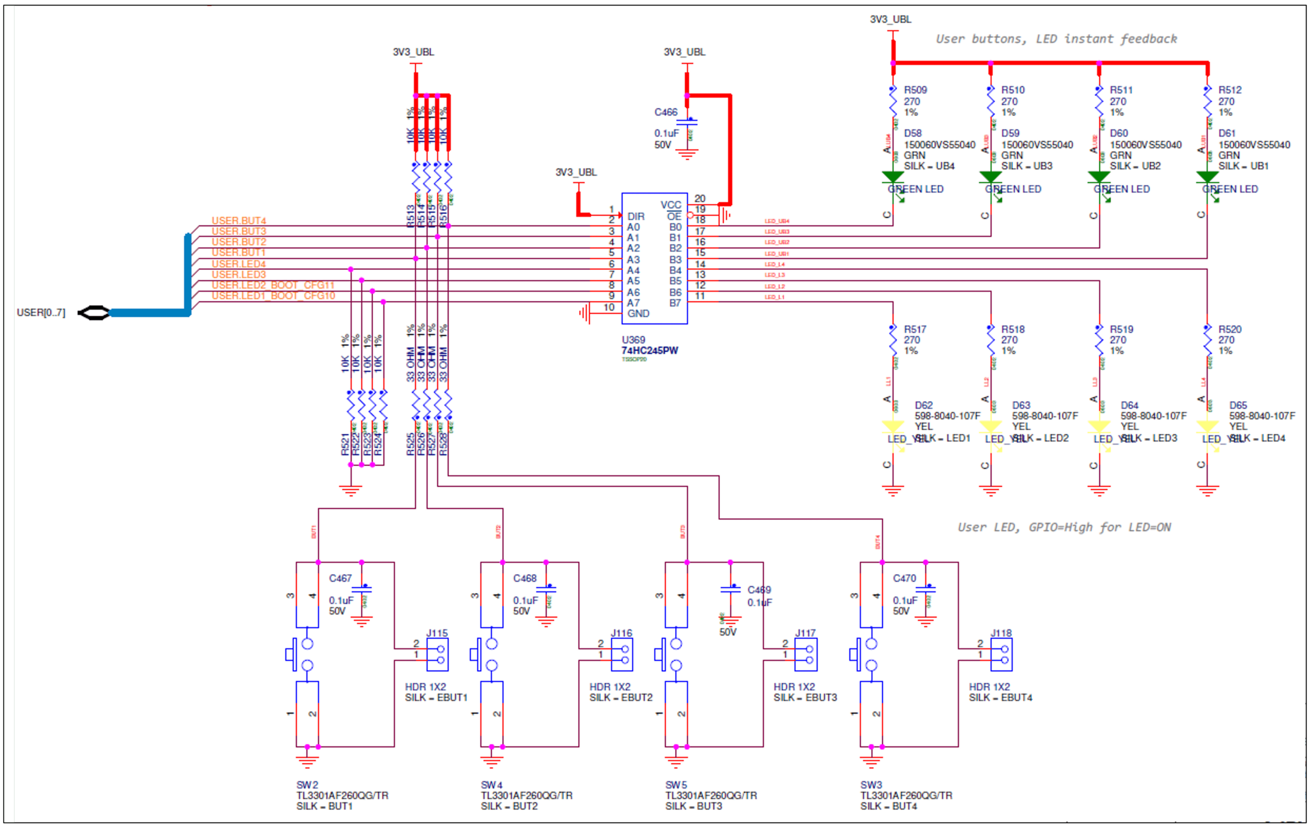

Figure 30. Digital board user buttons and LEDs - schematics

4 Power stage board hardware description

The **power stage board** is a general-purpose power board able to drive a single motor. It transforms the control commands into power signals to drive a PMSM servo motor (200W up to 450W), it handles PWM signals to generate motor phase voltages, it measures motor phase currents as a feedback for the motor control loop and also handles signals from position sensor.

Note: *For power ranges close to the upper limit, mechanical ventilation shall be used.*

The power stage board also has the ability to absorb the braking energy through the DC bus braking circuitry. Up to four power stage boards can be connected to the digital board to control up to four independent motors simultaneously.

This section describes the main hardware components and interfaces provided by the power stage board. A more detailed description of the board and its hardware configurations is provided in the *power stage board hardware design files*.

4.1 Power supply and DC bus brake

The power stage board must be supplied through an **external power source** using connectors *J6* (*VIN_MINUS*) and *J7* (*VIN_PLUS*). **The maximum voltage that should be applied is 30V.** The 5V power supply of the power stage board can be used to supply the digital board and the daughter card as well through the *J5* connector (see Section 3.1). Through the *J5* connector, the *PS_ON* signal from the daughter card enables the 16V and 3.3V power nodes of the power stage board, meaning that the inverter and GD3000 drivers will be ready to work.

The power stage board also provides a connector (*J8*) to plug a **DC bus braking resistor** for the motor. The default DC bus voltage level to activate the DC bus braking resistor is set to 53.5V. This does not allow users to apply the maximum power stage voltage as it is considered that a standard 48V motor is connected. In order to set different DC bus brake voltage threshold it is required to change configuration of *SH53, SH54* and *SH55*. For more details please refer to the power stage board hardware design files.

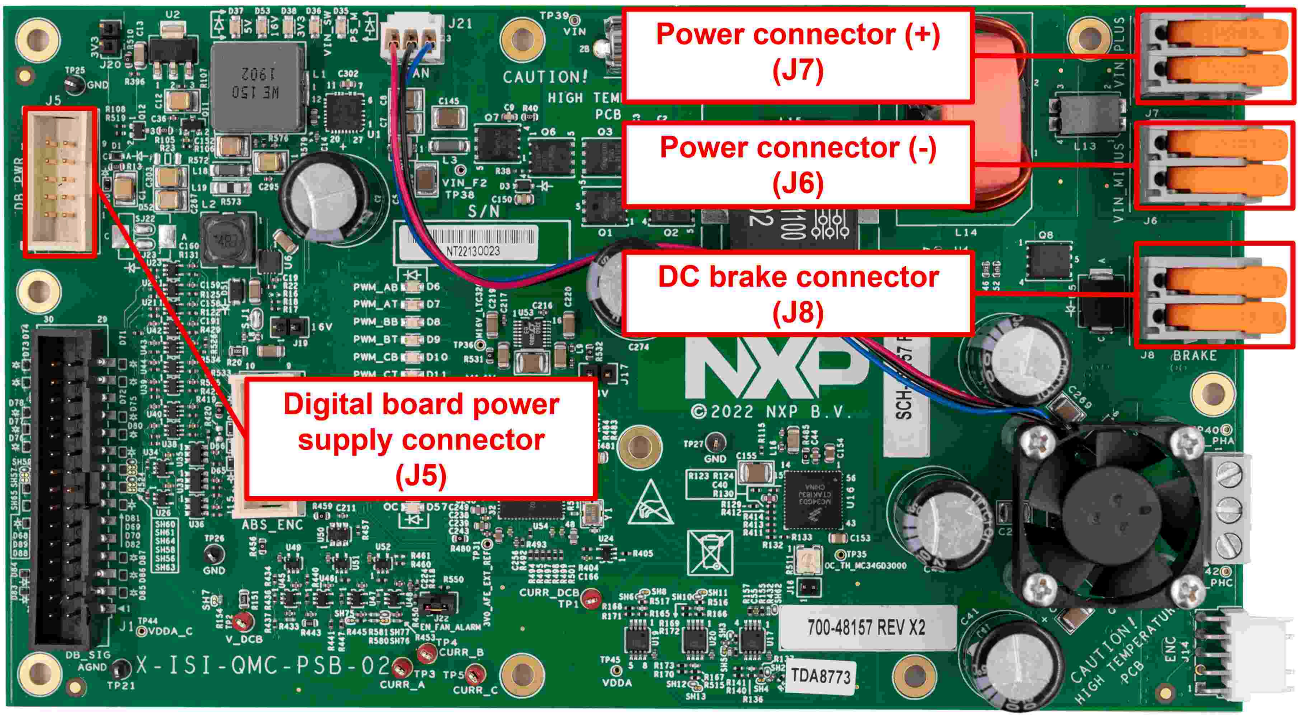

Figure 31. Power stage board power supply and management

4.2 Motor interface

The power stage board supports the connection of a PMSM through the *J13* connector shown in Figure 32 (screw terminal with conductor cross section 2.5 mm^2).

The three phases of the motor are controlled by NXP GD3000 gate driver IC (*U16*) which supports supply voltages up to 60 V and provides three half-bridge drivers (3-phase inverter), each capable of driving two N-channel MOSFETs. The gate driver uses 6 PWM signals (one PWM module) delivered from the daughter card MCU.

Note: *GD3000 has a frequency limit of 5 MHz. This must be taken into account when setting up the frequency of SPI master emulated by FlexIO. Please refer to the notes in Section 2.8.*

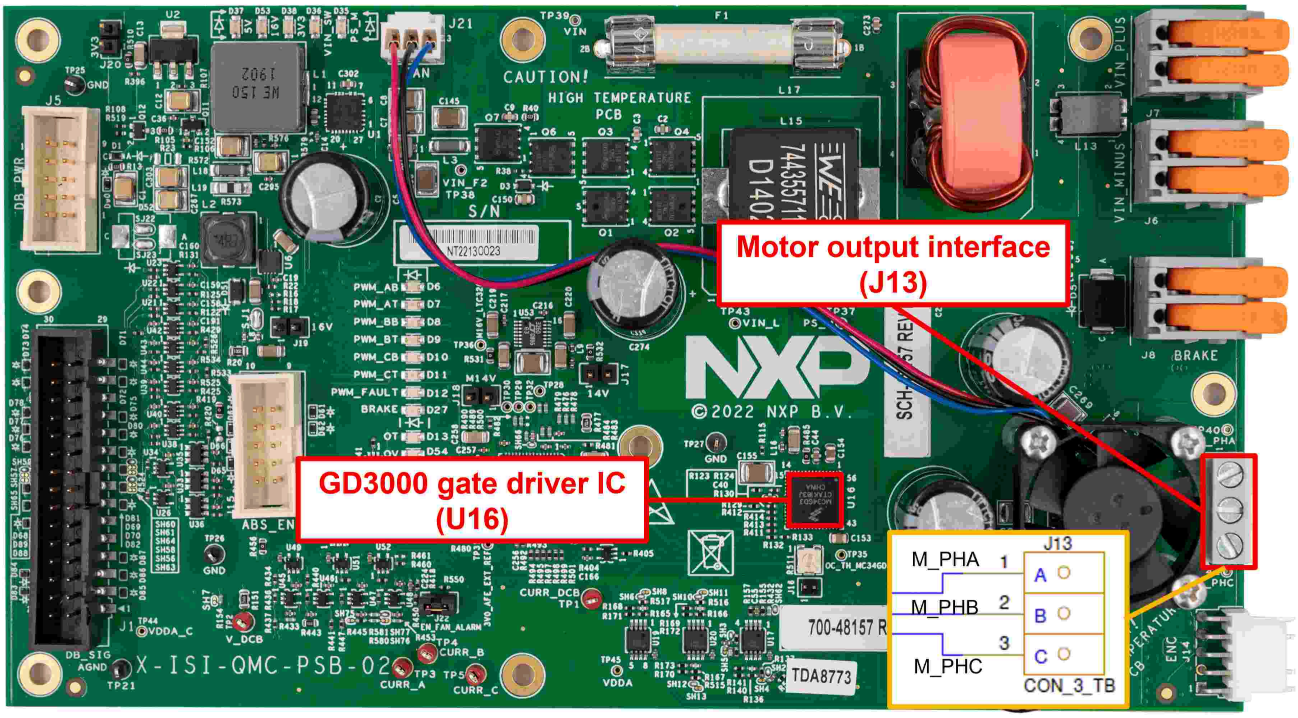

Figure 32. Power stage board motor interface

4.3 Incremental encoder interface

The power stage board provides connectors to connect an incremental encoder. The incremental encoder can be connected using the integrated 5-pin connector (*J14*) as shown in Figure 33.

Note: *The power stage board also provides a connector for an absolute encoder (J15). The connector is not meant to be used at this stage and it is only placed for future usage of the absolute encoder interface.*

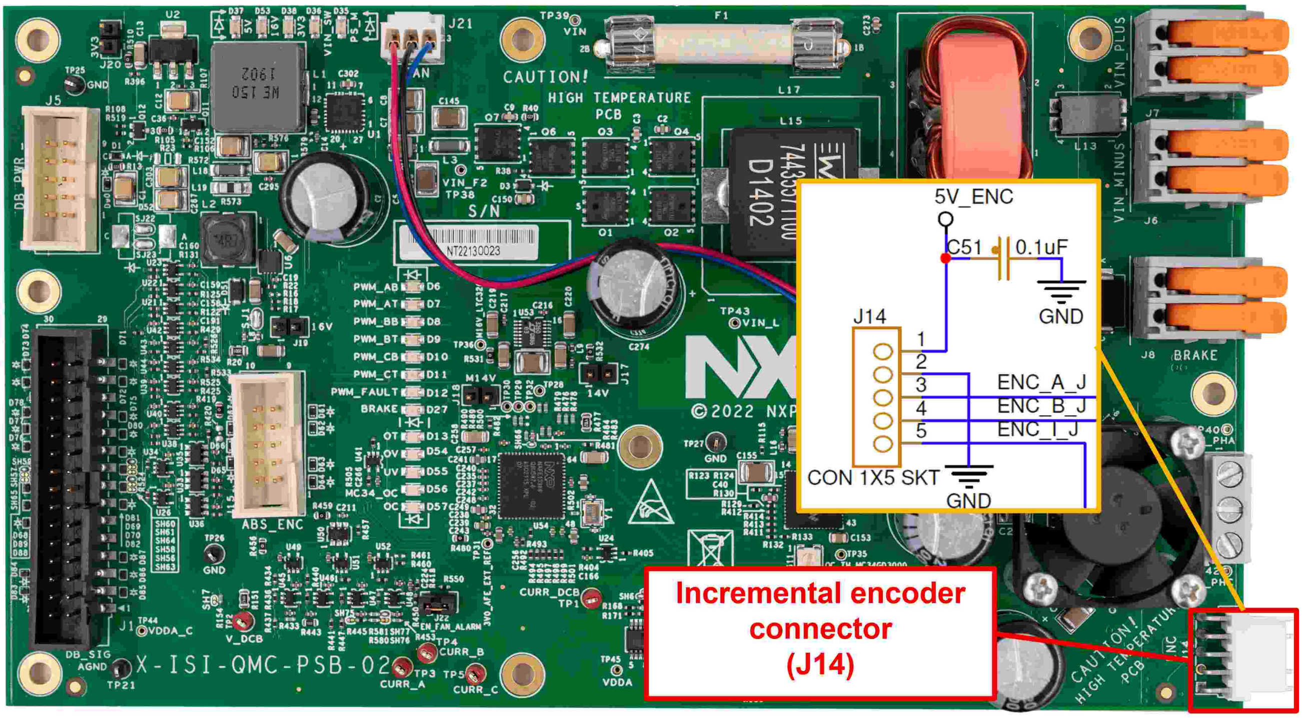

Figure 33. Power stage board incremental encoder and absolute encoder connectors

4.4 Analog frontend

The power stage board may integrate an **analog frontend IC (*NAFE11388 - U54*)** as shown in Figure 34. The analog frontend is used to measure the power of each of the power stages and also for measuring the temperature of the power stage board.

- **ISI-QMC-PSB02:** onboards a *NAFE13388* analog frontend IC. Purchase of this board is restricted. Please get in touch with your NXP representative if you are interested in purchasing ISI-QMC-PSB02.
- **ISI-QMC-PSB02B:** does not onboard a NAFE13388 analog frontend IC. The analog frontend chip can be soldered on the power stage board at a later time if needed.

Note: *For the SPI communication with the analog frontend we recommend not to go beyond 12 MHz. This must be taken into account if you change the frequency of SPI master emulated by FlexIO. Remember that analog frontend shares SPI communication with GD3000. Please refer to the notes in Section 2.8.*

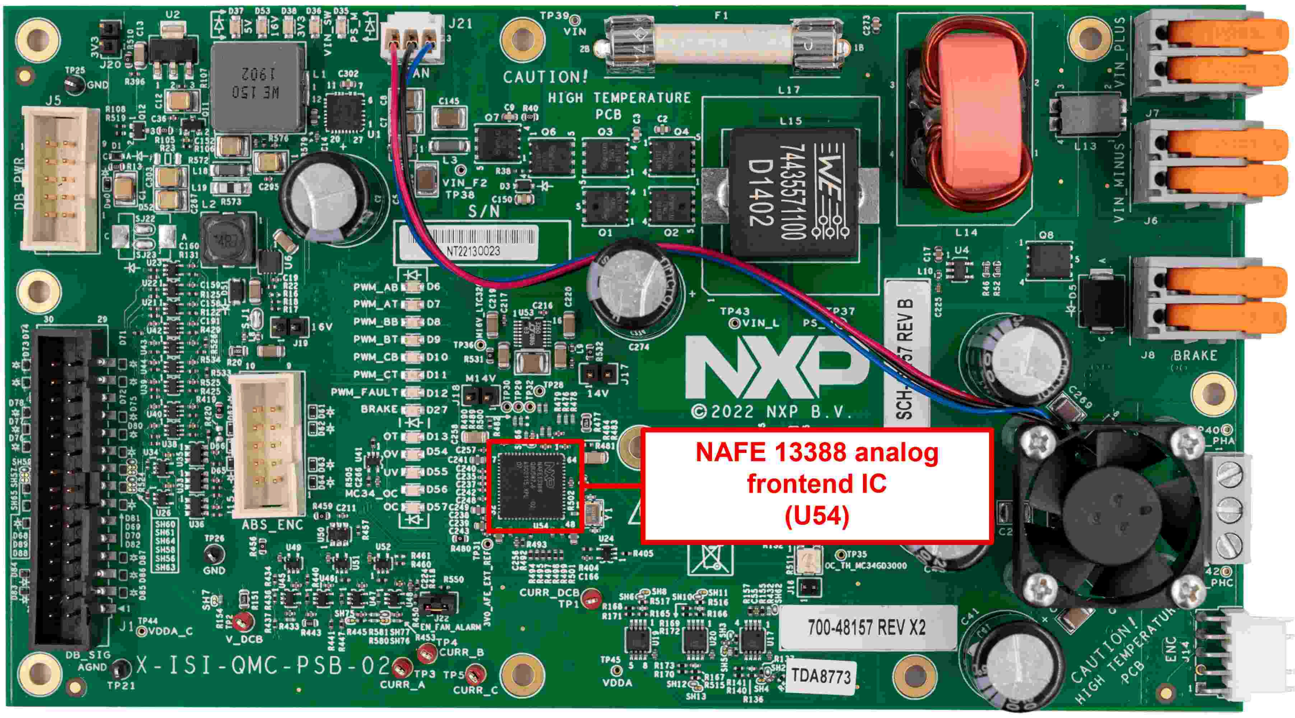

Figure 34. Power stage board analog frontend

4.5 LEDs

The power stage board provides several status LEDs as shown in Figure 35:

- **Power LEDs:** 5 green LEDs (*D35, D36, D37, D38, D53*) indicating the power supply status of the board, e.g. LED *D37* indicates presence of 5V power supply.
- **PWM signal LEDs:** 6 LEDs (*D6, D7, D8, D9, D10, D11*) indicating the PWM signals received by the power stage board.
- **Fault LEDs:** the power stage board provides protection circuits for over voltage, under voltage, over current and over temperature. 5 red LEDs (*D13, D54, D55, D56, D57*) indicate fault conditions respectively for Over Temperature (OT), DC Over Voltage (OV), DC Under Voltage (UV) and DC Over Current (OC). The *D12* LED indicates that any one of the faults happened (as a result of a logical OR operation).
- **DC bus brake:** a red LED (*D27*) indicating that DC bus braking is active.

Table 15 shows the thresholds for OV, UV, OT and OC. The OC threshold of *GD3000* can be configured through the *J16* jumper and the *R511* potentiometer. To do this, apply to *J16* the voltage required to simulate the maximum desired current that will pass through the shunt resistor *R138*. Then, adjust the *R511* potentiometer to set the desired OC threshold input of the *GD3000* (*OC_TH*) accordingly. The OC comparator of GD3000 will then compare the *OC_TH* and *AMP_OUT* signals to trigger OC. Schematics are shown in Figure 36.

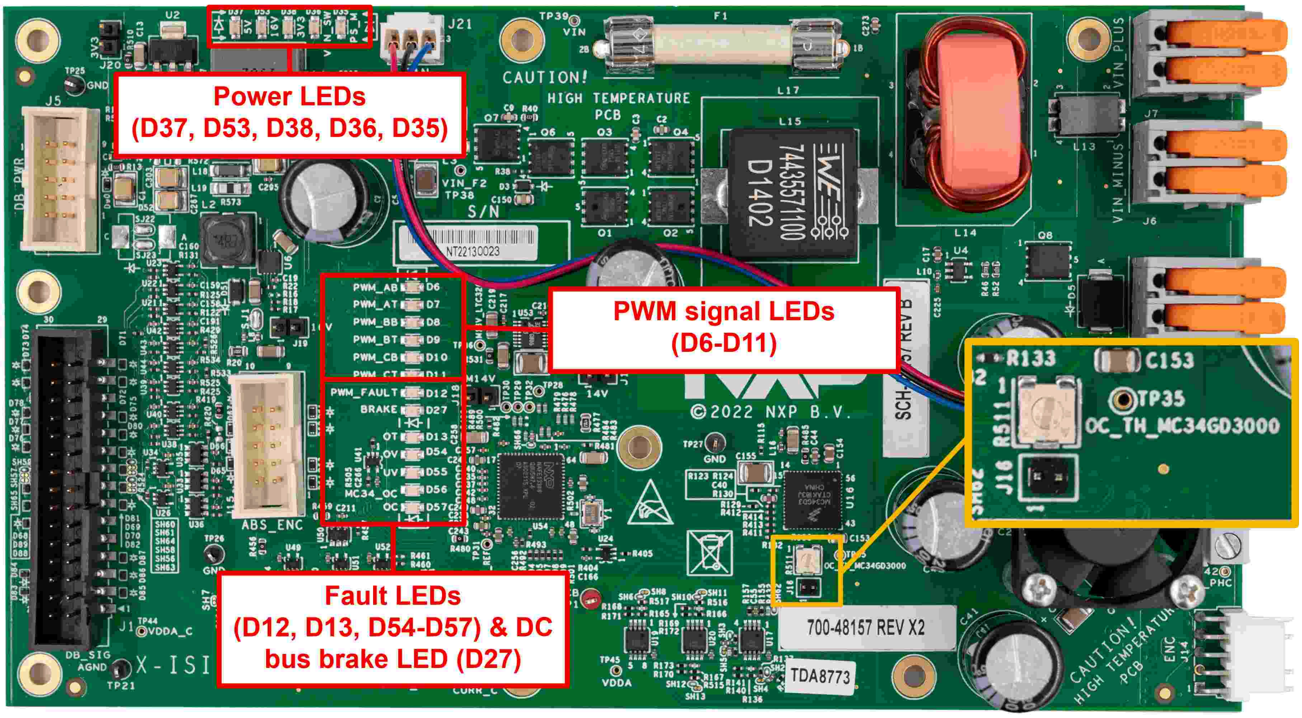

Figure 35. Power stage board LEDs

Table 15. Thresholds for OV, UV, OT, OC

Description	Hardware threshold
Over Voltage (OV)	56.95 V
Under Voltage (UV)	14.69 V
Over Current (OC) peak level	14.9 A
Over Temperature (OT)	120 C°

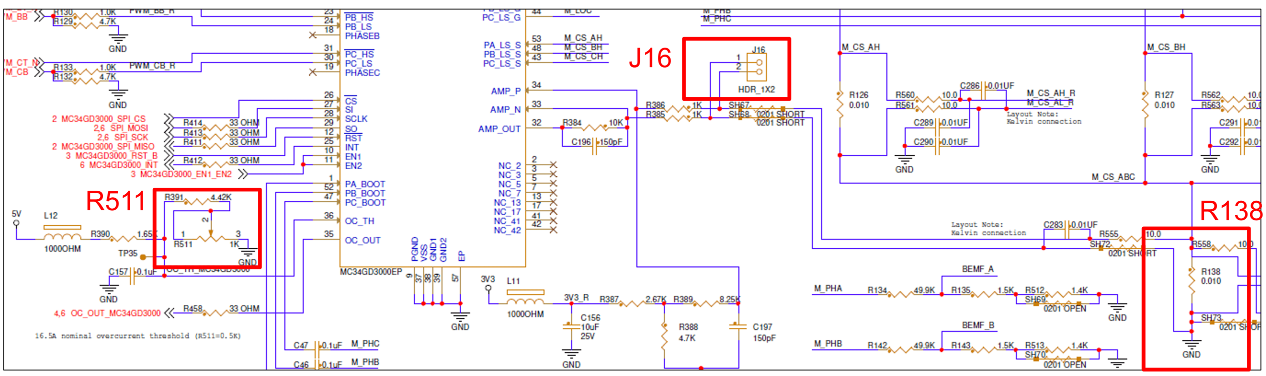

Figure 36. Configure GD3000 OC threshold

5 Physical enclosure

The i.MX RT Industrial Drive Development Platform, consisting of a daughter card, a digital board and 4 power stage boards, has been designed to be compliant with *ISA/IEC 62443-4-2 SL3*. For this reason, an enclosure has been designed with the objective of containing all the i.MX RT Industrial Drive Development Platform components and expose only the relevant interfaces. The enclosure contains:

- Openings for i.MX RT Industrial Drive Development Platform interfaces, e.g. LCD display, Ethernet port, SD card slot, motor connectors, fans, power supply connector, etc;
- 4 user buttons behind a keyed lid;
- 2 physical locks: one lock for the device supervisor to access the SD card slot and another for the device operator to access user buttons;
- An emergency stop button;
- An ON/OFF switch.

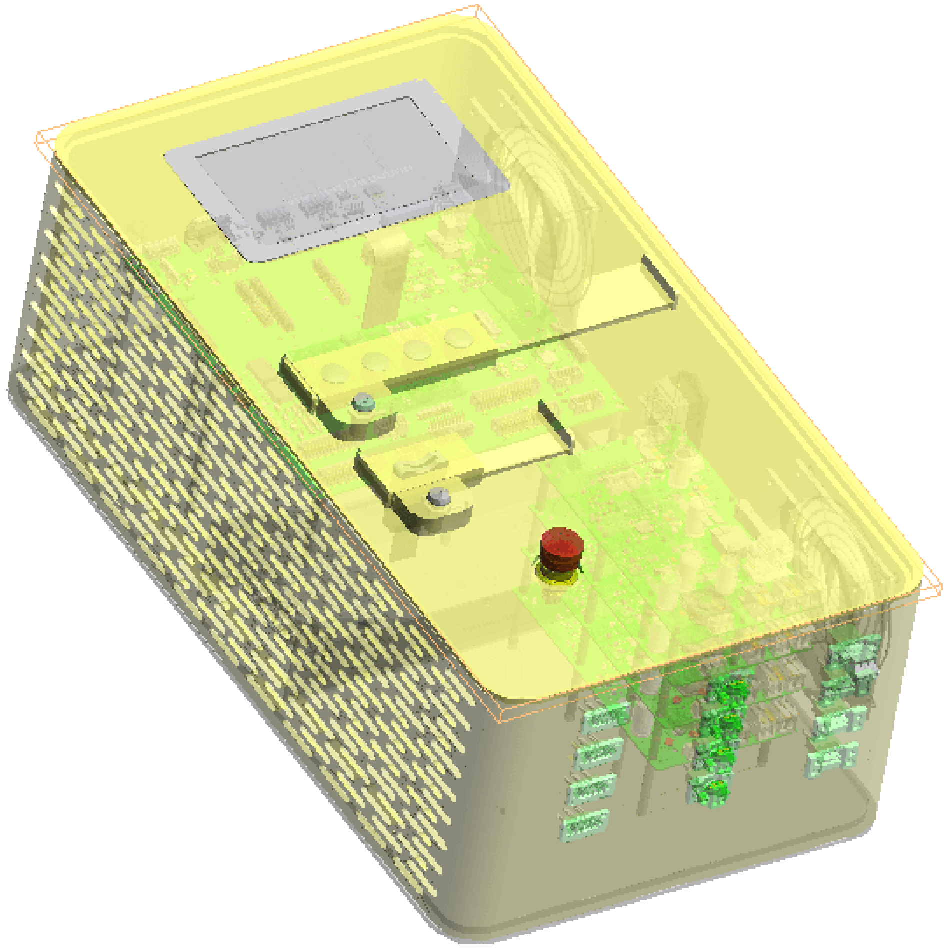

Figure 37. i.MX RT Industrial Drive Development Platform enclosure (3D model)

6 Abbreviations

Table 16. Abbreviations

Acronym	Description
ADC	Analog-Digital-Converter
CAN	Controller Area Network
DIP	Dual In-line Package

Table 16. Abbreviations...*continued*

Acronym	Description
DMIC	Digital Microphone
FD	Flexible Data
GPIO	General Purpose Input Output
HMI	Human Machine Interface
IACS	Industrial Automation and Control Systems
MCU	Micro Controller Unit
MIPI DSI	MIPI Display Serial Interface
OTG	On The Go
PMIC	Power Management Integrated Circuit
PWM	Pulse Width Modulation
RTC	Real Time Clock
SD	Secure Digital
SE	Secure Element
SNVS	Secure Non-Volatile Storage
SWD	Serial Wire Debug
TCM	Tightly-Coupled Memory
TSN	Time Sensitive Networking
XIP	eXecute In Place

7 Revision history

Table 17 summarizes the revisions to this document.

Table 17. Revision history

Document ID	Release date	Description
AN13642 v.1.2	19 March 2024	Updated with information related to the final hardware configuration. Fixed typos.
AN13642 v.1.1	12 September 2022	Updated part numbers for daughter card, digital board, and power stage board.
AN13642 v.1.0	10 August 2022	Initial release.

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